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Hydro news

The BULLETIN

The Hydro-Electric Power Commission of Ontario

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to XXVIII — to DECEMBER, 1941

2 vol. in 1

Havoc played by sleet on large maple trees.

Municipal Loads, December, 1939

NIAGARA SYSTEM

25-Cycle

	H.P.	Population
Acton	1,083	1,916
Agincourt	183	P.V.
Ailsa Craig	122	472
Alvinston	100	650
Amherstburg	940	2,869
Ancaster Twp.	427	V.A.
Arkona	59	406
Aurora	1,243	2,750
Aylmer	874	1,998
Ayr	219	755
Baden	360	P.V.
Beachville	509	P.V.
Belle River	179	810
Blenheim	604	1,775
Blyth	125	652
Bolton	190	567
Bothwell	146	643
Brampton	2,837	5,638
Brantford Twp.	910	V.A.
Bridgeport	128	P.V.
Brigden	82	P.V.
Brussels	156	780
Burford	212	P.V.
Burgessville	58	P.V.
Caledonia	404	1,410
Campbellville	37	P.V.
Cayuga	156	664
Chatham	6,944	16,153
Chippawa	320	1,186
Clifford	101	446
Clinton	599	1,901
Comber	143	P.V.
Cottam	86	P.V.
Courtright	50	334
Dashwood	88	P.V.
Delaware	69	P.V.
Delhi	781	1,677
Dorchester	119	P.V.
Drayton	131	551
Dresden	403	1,477
Drumbo	105	P.V.
Dublin	49	P.V
Dundas	2,202	4,956
Dunnville	1,363	4,004
Dutton	266	807
Elmira	719	2,069
Elora	367	1,149
Embro	94	428
Erieau	67	273
Erie Beach	10	21
Essex	495	1,833
Etobicoke Twp.	7,216	V.A.
Exeter	559	1,652
Fergus	1,190	2,785
Fonthill	182	829
Forest	494	1,502
Forest Hill	8,253	10,203
Galt	8,907	14,410
Georgetown	1,573	2,325
Glencoe	220	810
Goderich	1,385	4,488
Granton	60	P.V.
Guelph	11,017	21,333
Hagersville	546	1,307
Harriston	401	1,266
Harrow	437	984
Hensall	244	680
Hespeler	2,595	2,810
Highgate	91	349
Humberstone	557	2,629
Ingersoll	2,683	5,177
Jarvis	202	505
Kingsville	737	2,363
Kitchener	23,460	32,550
Lambeth	150	P.V.
LaSalle	191	812
Leamington	1,631	5,446
Listowel	1,150	2,826
London	39,901	74,281
London Twp.	596	V.A.
Long Branch	1,146	4,029
Lucan	196	614
Lynden	101	P.V.
Markham	362	1,116
Merlin	109	P.V.
Merritton	6,118	2,644
Milton	931	1,791
Milverton	362	1,006
Mimico	2,819	6,940
Mitchell	612	1,607
Moorefield	39	P.V.
Mount Brydges	110	P.V.
Newbury	36	279
New Hamburg	525	1,441
Newmarket	1,564	3,526
New Toronto	8,836	7,095
Niagara Falls	10,799	18,747
Niagara-on-the-Lake	508	1,651
Norwich	420	1,212
Oil Springs	223	470
Otterville	122	P.V.
Palmerston	567	1,410
Paris	1,755	4,325
Parkhill	185	997
Petrolia	1,185	2,711
Plattsville	103	P.V.
Point Edward	1,276	1,161
Port Colborne	2,091	6,348
Port Credit	883	1,751
Port Dalhousie	674	1,565
Port Dover	425	1,640
Port Rowan	102	659
Port Stanley	260	741
Preston	3,307	6,415
Princeton	115	P.V.
Queenston	131	P.V.
Richmond Hill	483	1,241
Ridgetown	636	1,956
Riverside	1,079	5,090
Rockwood	114	P.V.
Rodney	204	722
St. Clair Beach	69	110
St. George	136	P.V.
St. Jacobs	302	P.V.
St. Marys	1,425	4,017
St. Thomas	8,472	16,208
Sarnia	9,033	18,155
Scarborough Twp.	4,283	V.A.
Seaforth	621	1,708
Simcoe	2,928	5,826
Springfield	60	378
Stamford Twp.	2,519	7,840
Stouffville	269	1,115
Stratford	7,274	17,615
Strathroy	1,304	2,947
Streetsville	178	672
Sutton	181	852
Swansea	3,174	5,831
Tavistock	595	1,037
Tecumseh	275	2,245
Thamesford	188	P.V.
Thamesville	246	814
Thedford	108	593
Thorndale	54	P.V.
Thorold	2,558	4,904
Tilbury	588	1,980
Tillsonburg	1,499	4,376
Toronto	383,536	648,309
Toronto Twp.	2,735	V.A.
Wallaceburg	2,623	4,537
Wardsville	41	243
Waterdown	258	885
Waterford	499	1,238
Waterloo	4,269	8,425
Watford	302	975
Welland	6,587	10,924
Wellesley	126	P.V.
West Lorne	142	784
Weston	3,930	5,289
Wheatley	183	744
Windsor	41,658	102,704
Woodbridge	554	831
Woodstock	7,535	11,382
Wyoming	70	528
York E. Twp.	8,336	37,829
York N. Twp.	5,625	V.A.
Zurich	112	P.V.

THE
BULLETIN

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Hydro's Progress and Preparedness

By Dr. T. H. Hogg, Chairman and Chief Engineer,
The Hydro-Electric Power Commission of Ontario

NOTWITHSTANDING the tense European situation, which over-shadowed activity everywhere, the fiscal year of The Hydro-Electric Power Commission of Ontario, which ended October 31, 1939, was a year of encouraging progress. Towards the latter part of the year, it became increasingly evident that the recession of 1938 had apparently passed and peaceful industry was making progress towards better times.

Evidence of the increasing industrial activity throughout the province was reflected in increasing power loads. In fact, for some months prior to the declaration of war, Hydro experienced substantial increase in loads, and not Hydro alone, but other electric supply organizations across Canada. Since the war started these increases in load have not only continued, but have been augmented as plants manufacturing war materials here gradually increased their production.

It will be remembered that, due to the business recession of 1938, the primary power demand of the large Niagara system was virtually the same in October, 1938, as in October, 1937. But in October, 1939, the corresponding power demand of the Niagara system reached 1,228,000 horsepower, an increase of 142,000 horsepower or 13 per cent, as compared with October, 1938.

Other co-operative systems of the Commission recorded substantial increases in load, as well as the Northern Ontario Properties, to which more detailed reference is made elsewhere in this issue.

The aggregate primary loads of the co-operative systems and the North-

CONTENTS

Vol. XXVII No. 1
January, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

ern Ontario Properties increased from 1,484,615 horsepower in October, 1938, to 1,669,337 horsepower in October of the current year, a gain of 12.4 per cent. The primary load trend, which had shown a negligible rise in the previous year, started to point upwards at the close of 1938 and since has steadily gained ground. In the co-operative systems, commercial, domestic and rural demands have largely contributed to the upward trend, further aided in the last two months of the Commission's fiscal year by increases in industrial demands.

The total load in October, 1939, for all co-operative systems and the Northern Ontario Properties, including both primary and secondary loads, was 1,963,471 horsepower, the highest ever carried by the systems of the Commission and 7.2 per cent above the October peak of 1938. The total consumption of energy for all systems, including both primary and secondary power, amounted to 8,502,-000,000 kilowatt-hours, being 12.1 per cent in excess of that consumed in the previous year. This means that the greater portion of the Commission's power reserves, especially in the large Niagara system, found a ready sale in the secondary power market during the year.

The following table shows for the months of October, 1938, and October, 1939, the primary peak load of the co-operative systems and of the several districts of the Northern Ontario Properties. The accompanying graph shows for the past two years, the monthly primary peak loads of all systems combined.

Revenues and Expenditures

The financial results of the Commission's operations continued to be affected during the first half of the fiscal year ended October 31, 1939, by the industrial recession of 1938. In its effect on revenue, this recession was more severely felt during the early months of 1939 than during 1938. The revenue from sales of primary power to companies served by the Niagara system was about 10 per cent less during the first nine months of the 1938-1939 fiscal year as compared with the corresponding period 1937-1938. The recession also

Distribution of Primary Power to Systems

20-Minute Peak Horsepower—System Coincident Primary Peaks

System	October 1938	October 1939
Niagara—25-Cycle system	1,040,214	1,171,582
" —D.P. & T. division	46,515	56,970
Georgian Bay	30,891	34,756
Eastern Ontario	128,586	141,908
Thunder Bay	93,606	96,160
Manitoulin rural power district	205	273
Northern Ontario Properties:		
Nipissing district	4,857	5,188
Sudbury "	17,895	19,740
Abitibi "	113,160	130,968
Patricia—St. Joseph district	8,686	11,792
Total	1,484,615	1,669,337

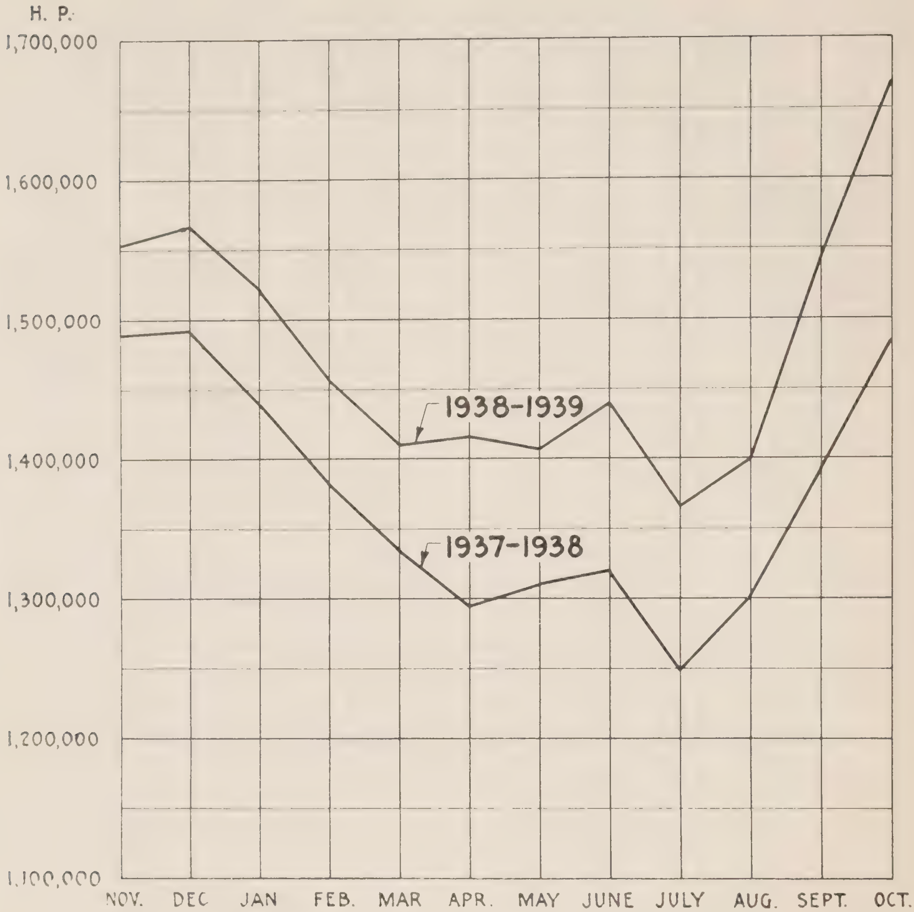
retarded materially the normal increase of power requirements by municipal utilities in these months.

Loss of revenue from primary power sales during this period was, however, largely offset by increased sales of secondary power and by moderate adjustments in interim rates to a few municipalities. In the closing months of the year a sharp upturn of demands also occurred. The net result of these factors was an increase of about $1,900,000 in revenue of the Niagara and other co-operative systems of the Commission,—an amount sufficient to meet the cost of scheduled increases in purchased power, the costs of general extensions of service throughout the systems, and also the special costs occasioned by the war-time civil security necessities.

Despite the difficult circumstances encountered, it is anticipated that the Commission will be able to set aside for its various reserves an aggregate amount nearly equal in total to that made in respect of 1938.

Estimated Summarized Operating Results of the Niagara, Georgian Bay, Eastern Ontario, and Thunder Bay Systems and also Nipissing, Sudbury and Manitoulin Rural Power Districts

Revenue	$32,521,000
Operation, maintenance, power purchased, administration and interest expenses	$26,687,000
Provision for depreciation and sinking fund	5,106,000
	$31,793,000
Balance available for contingencies, rate stabilization, etc.	$ 728,000



Primary peak loads, all systems combined.

REDUCED CAPITAL EXPENDITURE

Extensions to generating stations, transmission lines, rural distribution networks, storage works, etc., during the year necessitated a capital expenditure of about $9,334,000 as compared with nearly $11,000,000 in the previous year. Of this amount, more than half was incurred for the extension of service in rural power districts to which the Government contributed a grant-in-aid of $2,485,000. In the co-operative systems, apart from rural extensions, the chief capital expenditures were incurred for general extensions and additions to transmission lines and to transformer stations. In the Northern Ontario Properties, an extension to the Ear Falls development involved an expenditure of about $520,000. Other capital expenditures incurred in Northern Ontario were chiefly for extensions to transmission lines and transformer stations feeding mining properties.

ESTIMATED CAPITAL ADDITIONS
Year Ending October 31st, 1939

Niagara system	$2,512,000
Georgian Bay system	659,000
Eastern Ontario system	627,000
Thunder Bay system	202,000
Manitoulin and Nipissing rural power districts	32,000
Northern Ontario Properties	2,817,000
	$6,849,000
Provincial grant-in-aid for rural distribution	2,485,000
Total	$9,334,000

REDUCTIONS IN RATES TO CONSUMERS

In making its annual review of the operations of the local Hydro utilities, the Commission was able, in 1939, to recommend reductions in rates to a large number.

Out of 320 municipal utilities concerned, the consumers in 154 received reductions in rates which in the aggregate will result in an annual saving of about $167,000. A few small increases in rates were necessary in eight municipal utilities but the aggregate increased annual cost was less than $12,000.

In addition to the annual adjustments in rates to consumers, accumulated surpluses of certain utilities were reduced by refunds to individual consumers. These refunds amounted in all to nearly $210,000. Cash refunds to municipalities for municipal services, chiefly street lighting and waterworks, aggregated a further $147,000. It will be seen, therefore, that the finances of the local Hydro utilities continue in a healthy state.

EXTENSIONS IN RURAL POWER DISTRICTS

Applications for rural electrical service throughout the Province during 1939 equalled the annual records established the preceding two years. In all, more than 13,000 consumers were added to existing districts, necessitating the construction of 2,300 miles of primary lines. It is anticipated that this demand for service in established rural power districts will continue on a similar scale during the year 1940, and that much new rural territory in northern Ontario will be served during the coming year.

The load required to serve these rural systems is increasing rapidly. The aggregate load supplied to all rural power districts during 1939 amounted to 61,634 horsepower, an increase of 15.5 per cent over the year 1938.

SALES PROMOTION

During 1939, the Commission increased its sales promotion activities for the benefit of the municipalities which it serves. Under the guidance, and with the assistance of the Commission, a large number of the municipal utilities throughout the Province in turn increased their efforts to add to the uses of electricity made by their customers with very successful results.

The programme for the year combined advertising with direct field effort, promoting the further uses of electric power, in agriculture, industry, commerce and the home. Interesting and worthwhile features were the domestic appliance campaign during the early summer months, the commercial lighting surveys and the farm demonstrations in the rural areas. It is estimated that these promotional activities have added, over and above the normal increase, more than 16 million kilowatt-hours to the annual energy consumption of the Province.

During the coming year, the Commission's Sales Promotion Department will render its major service in industry by assisting plants to utilize Hydro power economically and efficiently and by further assisting new manufacturers to establish operations in Ontario.

War Efforts

No review of the past year's operations would be complete without reference to the steps taken to ensure that Hydro power will be available in ample quantities to enable Ontario to make its maximum contribution to the war efforts of Canada.

There are three main fields in which additional Hydro power can be used to expedite war-time production of needed supplies; first—in the mining fields of northern Ontario; second—in the manufacturing industries of southern Ontario; third—in the electro-chemical and electro-metallurgical industries.

War today is largely fought with machines made of metals and alloys. The production of nickel and copper, important war metals, has increased greatly in northern Ontario during recent years. Gold also may be considered a war metal of great importance and the spectacular growth in its production in Ontario, making a substantial contribution to the Dominion's financial strength, has been greatly fostered by low-cost Hydro electrical service. To-day, the reserves of hydro-electric power actually developed in northern Ontario are sufficient for normal growth for two years and many easily developed sites are available throughout the north.

The second field in which Hydro power may be needed in increasing amounts is in connection with the manufacturing industries of southern Ontario. Here the contract provisions made for increased supplies of purchased power would have taken care of normal growth in load for two years ahead. Deliveries of this power may, however, be advanced to meet war demands.

The third field in which Hydro power can be used to stimulate war production is in the electro-chemical and electro-metallurgical industries which supply many war-time needs. In this field the Commission can supply large amounts of at-will or secondary power without increasing its system capacity.

For the immediate future, therefore, there is ample power available in all districts to enable Ontario's war effort to be speeded up and maintained at a greatly enhanced level. During the past year many steps have been taken and plans made to insure that

this situation shall continue no matter what eventuates.

One important step taken was the passing by the Provincial Legislature of The Power Control Act. Under this Act The Hydro-Electric Power Commission of Ontario is given authority to regulate and control the generation, transformation, transmission, distribution, supply and use of all power in the Province. In brief, the object of this legislation is to give the Commission the necessary authority to regulate Ontario's power supplies so that they may make the maximum contribution to its wartime effort.

The Commission is also strengthening weak links in its extensive transmission systems by the construction of two or three strategic interconnecting and transmission lines of importance, both in eastern Ontario and in the western portion of the Niagara district. Careful consideration is also being given to industrial war demands, and continuous surveys are being made of industrial requirements in order to anticipate, if possible, any exceptional demands for war supplies of power, in order that all plants at present working on munitions, or likely to be doing so in the near future, may be guaranteed an adequate and reliable power service whenever and wherever it may be required.

* * * *

HYDRO'S PROGRESS IN NORTHERN ONTARIO

During the past year progress in the northern Ontario mining fields has continued the phenomenal growth experienced for several years. This growth has resulted in a great increase in the demand for Hydro power. From October, 1938, to October, 1939, the total primary load in the districts served by the Northern Ontario Properties rose from 145,000 horsepower to 168,000 horsepower, an increase of 16 per cent; this followed increases of 19.6 per cent in 1938 and 19.7 per cent in 1937. The total increase in primary load of the Northern Ontario Properties during the past four years has exceeded 100,000 horsepower or more than 150 per cent. These figures include municipal loads in northern Ontario but do not include the loads sold in the Beardmore and Longlac mining areas, which are supplied by the Thunder Bay system. The actual increase in the total load sold to mining companies during the fiscal year was 23,801 horsepower, from 127,986 horsepower to 151,787 horsepower or 18.6 per cent.

FINANCIAL OPERATING RESULTS

The revenues and expenditures of the Northern Ontario Properties increased considerably during the fiscal year. As compared with the previous year, revenues, estimated at $4,179,000, are up nearly 23 per cent., while expenditures, at $2,153,000, increased about 10.5 per cent. Reserves for depreciation and sinking fund were $1,469,000, compared with $1,269,000, and the balance available for contingencies, etc., totals $557,000 as compared with $185,000 in 1938.

The districts served by the Northern Ontario Properties are scattered over wide areas of northern Ontario and long transmission lines have been built to connect these districts with the various sources of hydro-electric

ESTIMATED SUMMARIZED OPERATING RESULTS OF THE NORTHERN ONTARIO PROPERTIES

Revenue	$4,179,000
Operation, maintenance, power purchased, administration and interest expenses	$2,153,000
Provision for depreciation and sinking fund	1,469,000
	$3,622,000
Balance available for contingencies, etc.	$ 557,000

power. Owing to the great distances involved, it is not economically practicable at the present time to weld the whole of the transmission networks of the Northern Ontario Properties into one physical entity. As time goes on, however, and more mining areas are developed at intermediate points, it is certain that interconnection of the districts will be accomplished to a greater degree. During the past year, for example, the Patricia and St. Joseph districts, which obtain their power supplies and thus to reinforce each other, providing a more reliable service.

Similarly in the Nipissing and Sudbury districts, interconnection has been arranged between the power plants on the South river serving the Nipissing district and those on the Wanapitei river serving the Sudbury district with 60-cycle power.

The following table shows for the months of October, 1938, and October, 1939, the primary peak loads of the several districts of the Northern Ontario Properties.

DISTRIBUTION OF PRIMARY POWER TO NORTHERN ONTARIO PROPERTIES
20-Minute Peak Horsepower—District Coincident Primary Peaks

System	October 1938	October 1939
Northern Ontario Properties:		
Nipissing district	4,857	5,188
Sudbury district	17,895	19,740
Abitibi district	113,160	130,968
Patricia-St. Joseph district	8,686	11,792
Total	144,598	167,688

from the Ear Falls and Rat Rapids developments, have been connected by a transmission line extending from Uchi to Crow river, a distance of 113 miles. This connecting link enables the two developments, Ear Falls and Rat Rapids to be operated in parallel

The increased load sold to mining properties in 1939 over 1938 for the Abitibi district, including the mining camps at Porcupine, Kirkland Lake, and Larder Lake, Matachewan, Ramore and Sudbury was 20,108 horsepower. The increased load sold in

1939 in the Patricia-St. Joseph district, which includes the Red Lake, Woman Lake and Pickle Lake mining areas, was 3,612 horsepower. The increase in the 60-cycle load sold to mining properties in the Sudbury district was 81 horsepower.

Taking into consideration the mining properties which had been abandoned or closed down, the total number of active contracts at October 31, 1939, was 54, a net increase of six during the year.

To provide for the growth in load in the mining areas served by the Northern Ontario Properties, it has been necessary for the Commission constantly to increase generating plant capacity, to construct additional transmission lines, to enlarge existing and construct new transformer station, and in general, to re-arrange in many instances the entire set-up under which power delivery has been made. In fact, the increase in the power demand from both existing and new mining properties has been so rapid that it has been difficult to provide plant and equipment fast enough to prevent embarrassment to mining operations, from the standpoint of power supply.

New works constructed in 1939, or under construction at the end of the year to provide for increased loads included the following:

In the Abitibi district, a new 15,000 kv-a. transformer station at Timmins replacing a 9,000 kv-a. station; a loop transmission line out of the Timmins transformer station; a new bank of three 9,000 kv-a. transformers at Kirkland Lake, increasing its capacity to 57,000 kv-a., and a new 1,000 kv-a. transformer station at Westree to supply power to the Tyranite and Ronda mines.

In the Patricia-St. Joseph district, which serves the mining areas of Red Lake, Woman Lake and Pickle Lake, a third generating unit was installed at the Ear Falls development which will be placed in operation in January, bringing the total installed capacity at Ear Falls to 17,500 horsepower. A new 44 kv. transmission line 48 miles in length was placed in operation between Ear Falls and Uchi mine in the Woman Lake district. The new transmission line between the Uchi mine and Crow river, near the Central Patricia mine, which forms the connecting link between the Ear Falls and Rat Rapids developments, was completed, and a 3,750 kv-a. transformer station at its terminus was placed in operation in September, 1939. In addition the Commission purchased all the transmission lines belonging to individual mining companies in the Red Lake district and now controls and owns all of the transmission system originating out of the Ear Falls development.

The accompanying map (see pages 16 and 17) clearly indicates the Commission's extensive service in northern Ontario, originating from thirteen individual hydro-electric developments, and utilizing 1,600 miles of transmission lines to deliver this power to mining customers.

Ear Falls power development, before the addition of the third generating unit.

Ear Falls Power Development

By J. J. Traill, Assistant Engineer, Hydraulic Dept., H.E.P.C. of Ont.

THE Ear Falls Development, in which a third unit has been brought into service during the last few days, is located on the English river at the outlet of Lac Seul in the District of Patricia. The English river is one of the large tributaries of the Winnipeg river, on which latter are located a number of power developments in the Province of Manitoba, serving Winnipeg and other parts of the province. In 1928-29 a conservation dam was built at the outlet of Lac Seul, the Governments of the Dominion of Canada and of the Province of Ontario co-operating. The primary purpose of the dam was regulation of the outflow of the lake for the benefit of present and future developments farther downstream on the English river and on the Winnipeg river. The dam creates a storage basin having a capacity of 3,300,000 acre-feet between its minimum and maximum levels, which is sufficient to effect almost complete regulation of the outflow from the lake.

The design of the dam was such as to provide for future development of water power at the site, if this demand should arise, and as the development of mining properties in the neighbourhood had been proceeding during the period of construction of the dam, the necessity for power to serve them was apparent early in 1929. The initial construction for development of power consisted of the installation of a single unit having a capacity of 5,000 horsepower under a head of 36 feet. The unit was first placed in service on Christmas day, 1929.

This part of the development comprises two wood-stave pipes, 12 feet in diameter, connecting two of the power sluices provided in the dam with the concrete turbine casing formed in the

power house substructure, in which is installed a fixed-blade propeller type turbine built by the Dominion Engineering Company of Montreal. The turbine is rated at 5,000 horsepower, 180 r.p.m., under a head of 36 feet, and is directly connected to a Canadian Westinghouse Company's generator, where power is generated at 6,600 volts. A transformer station stepped up the voltage to 44,000 volts for transmission of the entire plant output to the Red Lake mining district some forty miles distant.

A second generating unit, similar to the first in style and capacity, was added to the power house, coming into service in the summer of 1937, the turbine and generator in this case being built by the S. Morgan Smith-Inglis Company and Oerlikon, respectively. The addition of the second unit necessitated an entire redesign of the electrical control and protection systems and the high and low voltage switching arrangements. Provision was made in the redesign for the future installation of generating units up to the capacity of the development. It is interesting to note that from the time the first unit came into service in December, 1929, until 1937, when the second unit was available, continuous service was given without interruption, except for a few very brief shutdowns for inspection—a very excellent operating record.

From time to time during the interval between the installation of the first and second units, extensions of the transmission line were made to serve others than the original customer of the Development. Over a year ago it became quite apparent that a further extension of the plant would be necessary to cope with further prospective growth of load. As four of the eight sluices available for power development had already been made use of in the first two units, it became necessary to plan the capacity of the third and fourth units to correspond with the ultimate plant capacity. Based on data collected during the past ten years of operation, supplemented by that available when the original development was undertaken, it was decided to design units 3 and 4, each with a capacity of 7,500 horsepower, making a total installation of 25,000 turbine horsepower, and proceed at once with the construction of No. 3 unit.

While the design for the No. 3 unit extension is somewhat similar to that used for units 1 and 2, important changes in details have been made. Rectangular conduits of concrete were built instead of wood-stave pipes as used for the first two units. Satisfactory experience elsewhere with Kaplan, or movable-blade propeller type turbines, resulted in a selection of this type for the new installation. The turbine, supplied by the S. Morgan Smith-Inglis Company, Limited, is rated at 7,500 horsepower at 150 r.p.m., and will have a high efficiency over a much greater range of its capacity than is the case with the fixed-blade propeller turbines in use in units 1 and 2. The direct-connected generator was supplied by the Canadian Westinghouse Company, Limited.

Further extensions of the transmission lines have been made: one to serve the towns of Sioux Lookout and

Hudson to the south-east of the development; another to the north-east to Uchi, a distance of 48 miles; and beyond this to Crow River near the Central Patricia mine, a further distance of 113 miles, where a connection is made to the transmission system from the Rat Rapids development located on the Albany river at the outlet of lake St. Joseph. In addition to the supply of power to the Crow River area, the 161-mile transmission line between the two plants provides a source of power for possible future mining development over a large territory.

Trees—Another Version

If ne'er again I see a tree
My soul will rise in ecstasy,
To ne'er again behold green spire
Touching a Hydro tension wire,—
I'll lift my voice to God in thanks
That nature can't play any pranks.

A tree that may in Summer bloom,
But to 'lectricians just bring gloom,
We lie awake at night and dread
The swaying bough up over head
And pray the Town will soundly tax
Each tree that is not felled by axe.

And may these lovers of a tree
Have sympathy with you and me,
These men who work to give you power,
And toil along through nightly hour
Without their supper or their bed
Can you blame them to wish trees dead?

They have a love of nature too,
But must co-operate with you,
So you in kind must do the same,
If pruning must be done, don't blame
These men, just hope and pray
For Hydro power every day.

—EDITH VAN LONE DERHAM.

Hydro-Electric Progress in Canada in 1939

THE annual review of hydro-electric progress in Canada prepared by the Dominion Water and Power Bureau, Department of Mines and Resources, shows that considerable activity took place not only in the installation of new generating capacity but also in the extension of transmission and distribution facilities in many parts of the Dominion. There was, as well, a substantial increase in the demand for power reflecting steady growth in domestic use and increased activity in mining, pulp and paper and many other industries. Production of electric energy in fact established all-time records during the year. This is indicated by the monthly figures of output of central electric stations compiled by the Dominion Bureau of Statistics. Each month of 1939 showed an increase over the corresponding month of 1938, and for the ten-month period, January-October, 1939, an aggregate increase of more than nine per cent was recorded. Increased demand due to war activities had not been experienced to any material extent during this period but such activities will lead, undoubtedly, to substantially increasing loads. With existing generating facilities and those being provided the industry appears to be favourably situated in most areas to meet increasing demands.

New water-power installations in 1939 aggregated 97,040 horsepower, which with an installation of 1,400 horsepower by the Dryden Paper Company at McKenzie falls on the Eagle river in northwestern Ontario, omitted from the 1938 review, brings the total for the Dominion at the end of the year to 8,289,212 horsepower.

The greater part of the increase, amounting to 87,441 horsepower, was made up of extensions to existing stations in Saskatchewan, Ontario and Quebec. New developments included a 3,300 h.p. plant of Consolidated Mining and Smelting Company Limited at Wellington Lake in northern Saskatchewan; a 2,000 h.p. plant of Berens River Mines Limited on Duck river in northwestern Ontario; a 1,500 h.p. plant of Ontario Paper Company Limited on Black river near Heron Bay in northern Ontario; a 999 h.p. plant of Gananoque Electric Light and Water Supply Company Limited on Cataraqui river, Ontario; a 700 h.p. plant of La Sarre Power Company on La Sarre river, Quebec; a 600 h.p. plant of the Town of Bridgewater on Petite Riviere, Nova Scotia, and a 500 h.p. development of the Nova Scotia Power Commission on Barrie Brook, Nova Scotia. Extensions to existing plants are described hereunder.

In Saskatchewan, the Churchill River Power Company completed the addition of a fifth unit of 19,000 horsepower to its plant at Island Falls on the Churchill river. The

three original 14,000-horsepower units in this plant were also rebuilt and converted to 16,500 horsepower. The fifth unit and the rebuilding of the other three units resulted in an addition to the capacity of the plant of 26,500 horsepower. The total installed capacity is now 87,500 horsepower.

In Ontario the Hydro-Electric Power Commission, as trustee for the Provincial Government, completed the installation, in December, of a 7,500-horsepower unit in the Ear Falls station on English river, thus bringing the installed capacity to 17,500 horsepower.

The Beauharnois Light, Heat and Power Company brought into operation the ninth unit of 53,000 horsepower in its plant at Beauharnois on the St. Lawrence river.

Lighting in the Hospital

By Harvey Agnew, M.D., F.A.C.H.A.
Secretary, Department of Hospital Service, Canadian Medical Association

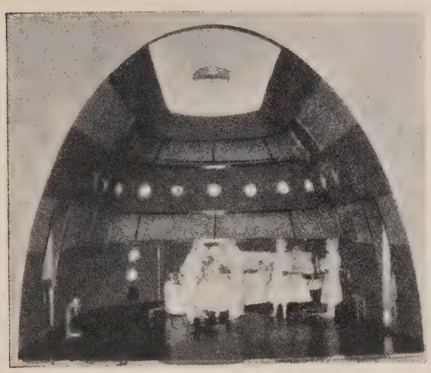
IN few places have the many revolutionary developments in lighting been so freely applied as in the modern hospital. Think of what goes on in the hospital. Nearly every development can be applied—home, office, workshop lighting—and in addition there are the multitudinous lights for scientific work, ranging from the tiny "grain of wheat" lights on the ends of tubes inserted into nose, bronchial tubes or bladder to great operating room installations costing many hundreds of dollars.

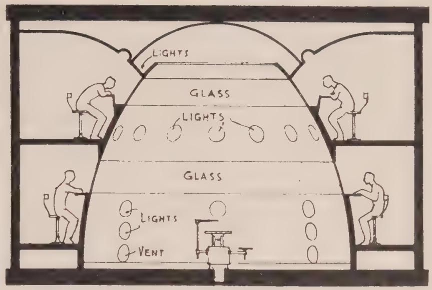
At the present time drastic changes are taking place in hospital lighting in Great Britain as a result of new conditions brought about by the war. For instance, the "blackout" precautions have necessitated the development of some way of carrying on essential hospital work without permitting the bright light to escape to the outside. It has been found, for instance, that if the outside windows be made blue either by the application of a blue film such as rhodoid or a blue translucent paint such as dalo, orange or pink light coming from within cannot be seen through this glass. In the case of rhodoid they put pink shades on the lights whenever the air siren blows, and in the case of dalo they use orange lights. They have had to develop "light-locks" at ambulance doors, and have also developed very handy little emergency battery lamps for these occasions.

From an addess to the Illuminating Engineering Society, Toronto, November 20, 1939.

Operating Room Lighting

The tendency to-day is to use artificial light at all times. More reliable than natural lighting, it has the added advantage of permitting the rays to be directed as required by the surgeon. Old, leaky skylights are now a thing of the past, and it is prophesied that before long we shall see very few of the large frosted glass windows which





Figures 1 and 2—Operating Room of Future. At the Chicago Century of Progress Mr. Carl A. Erikson showed a model of the operating room of the future. It has no outside windows, lights can be turned on from any direction as desired, students are behind glass windows and placed almost over the operating table. The room is air conditioned. There is a two-way amplifier communication for conversation between the surgeon and the gallery. There is television equipment in the dome and photo-electric cells to permit the calling of outside nurses and the opening of doors to permit the passage of "sterile" doctors and nurses.

for many years have been so typical of hospitals. Many of our newer institutions put ordinary windows only in their operating rooms, and many authorities prophesy that the time will soon come when operating rooms will have no outside windows whatsoever. (See Figs. 1 and 2). One very modern operating room in Rochester, N.Y., has a glass brick outside wall, thus permitting a soft general illumination, the operative field being illuminated entirely by artificial light.

In choosing the lighting for an operating room several very important factors must be kept in mind:

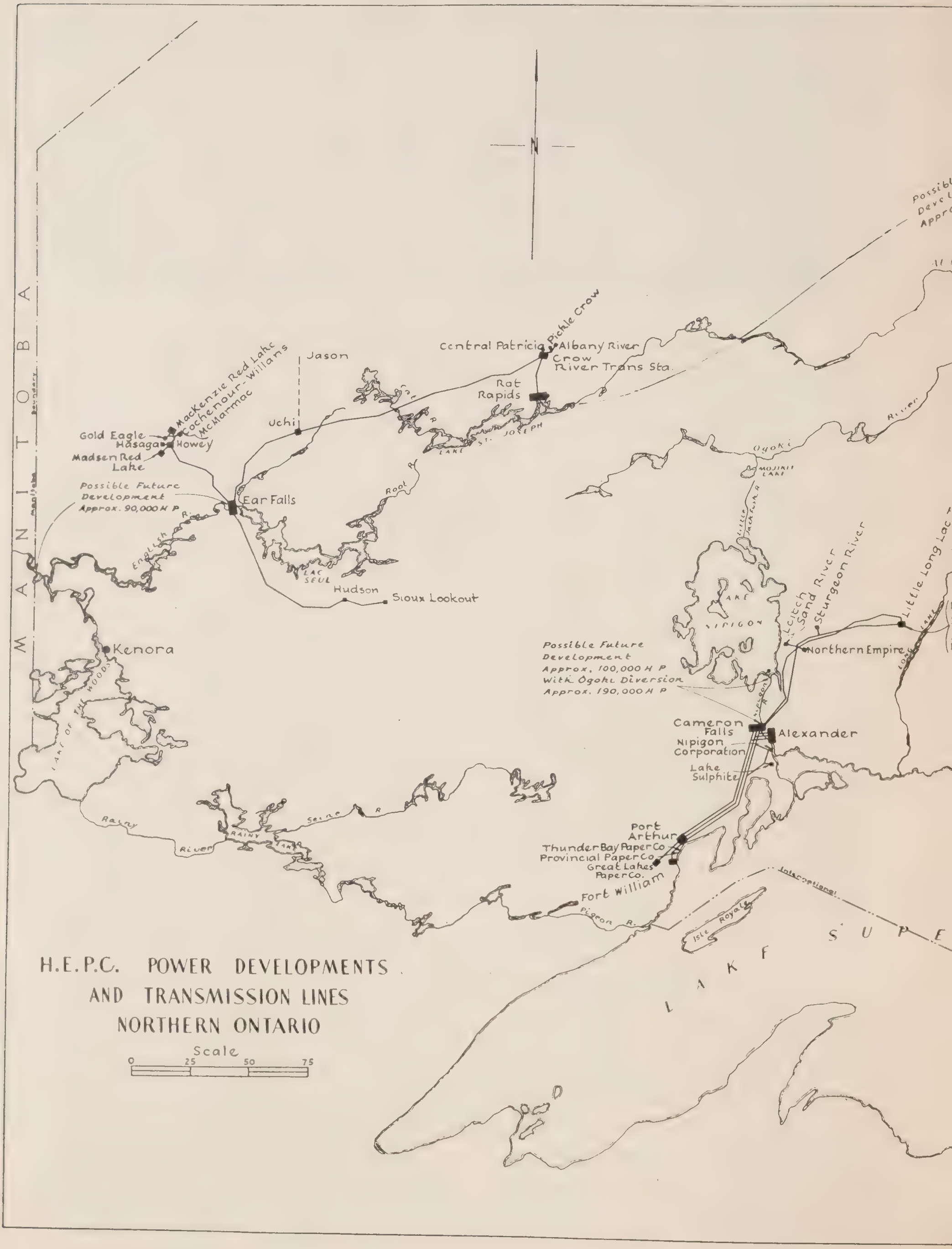
1. Adequate light in the surgical field is needed—down into the cavity and at the required angle.
2. Glare must be avoided.
3. There must be a minimum of shadow.
4. Heat radiation should be low.
5. The room should have adequate general illumination.
6. There must be adequate emergency protection against light failure.

Strong Lighting Required:

Body organs have a high *absorption index*—very little light is reflected. Also the *contrast ratio* of exposed organs is low; that is, the details are not distinct as is this print on paper. Moreover the surgeon at sixty requires three times the light required by his nurse or intern in the early twenties. For these reasons very strong lighting is required.

The surgeon, also, is often working down in a small hole which may be seven or eight inches deep. When we

(Continued on page 18)



H.E.P.C. POWER DEVELOPMENTS
AND TRANSMISSION LINES
NORTHERN ONTARIO

Scale
0 25 50 75


James Bay
River
River
River
Possible Future Development Approx. 166,000 H P
Boundary
Little Abitibi R
Abitibi Canyon
River
Missinaibi
Abitibi
QUEBEC
Smooth Rock Falls
Hunta
Lake Abitibi
Mattagami
Pamour
Hoyle
Broulan
Hallnor
Porcupine Lake
Iroquois Falls
Hollinger
Ramore Trans. Sta.
Pamour Trans. Sta.
Timmins Trans. Sta
Moneta
De Santis
Delnite
Aunor
Faymar
Ankerite
Paymaster
Preston East Dome
North Whitney
Canadian Northern Power
Bidgood
Golden Gate
Crescent Kirkland
Continental Kirkland
Lakeside Kirkland
Glenora
Kirk Gold Rand
Kirkland Lake Trans. Sta.
Omega
Barber-Larder
Kerr Addison
Chesterville
Young Davidson
Matachewan Consol.
Matachewan Trans Sta
Larder Lake Trans Sta
Kapuskasing
Tyranite
Ronda
Shining Tree Trans. Sta.
Canadian National Rlys
Capreol
Falconbridge Nickel
Falconbridge Trans Sta
Stinson
Crystal Falls
North Bay
Callander
Bingham Chute
Elliot Chute
International Nickel
Coppercliff Trans Sta
Sudbury
Coniston
McVittie
Nippissing
French R.
Lake Nipissing
Possible Future Development Approx 27,000 H. P.
Possible Future Development Approx 57,000 H.P.
Sault Ste Marie
Manitoulin Is.
Lake Huron
Georgian Bay
Ottawa R
Montreal R.
Michipicoten R
Mississagi
Spanish R.

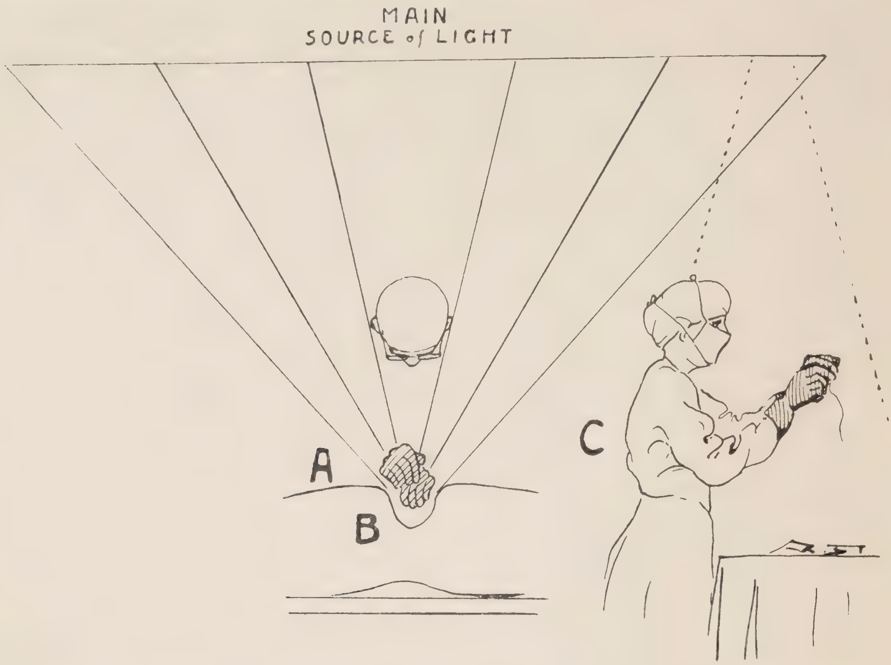


Figure 3—Three Principles in Operating Room Lighting.

A—The wider the angle the less the interference by the surgeons' hands and head. This light may be from one single unit or from several focused lights.

B—The essential purpose is to get light into the cavity—not on the surface.

C—The rest of the room should not be so dark that the nurse cannot thread needles, etc. Smaller additional lights may be needed.

think of three or four gloved hands, a couple of retractors, a dozen or more forceps and several cotton sponges a yard or more long crowding into this hole, we realize how strong and how well focused the light must be to penetrate down. Therefore, we need 1,000 and even up to 2,000 foot-candles at the "operative field".

Glare:

This brings up the question of *glare*. This is apt to be quite severe at 1,000 f.c. and naturally worse at 2,000 f.c. One disadvantage of glare is that it contracts the pupil of the eye, just as if one were out on a snowy road in brilliant sunshine. When the pupil is contracted, the amount of light entering the eye is naturally reduced and therefore 2,000 f.c. gives no better vision of the inside of the abdomen, if the pupil of the eye be closed, than if the pupil be open and only 1,000 or even 500 f.c. be available. Every camera enthusiast understands this problem. Therefore, if we have glare, we nullify the effect of the greater intensity of light.

How can we avoid glare? Glare and loss of vision may come from mis-

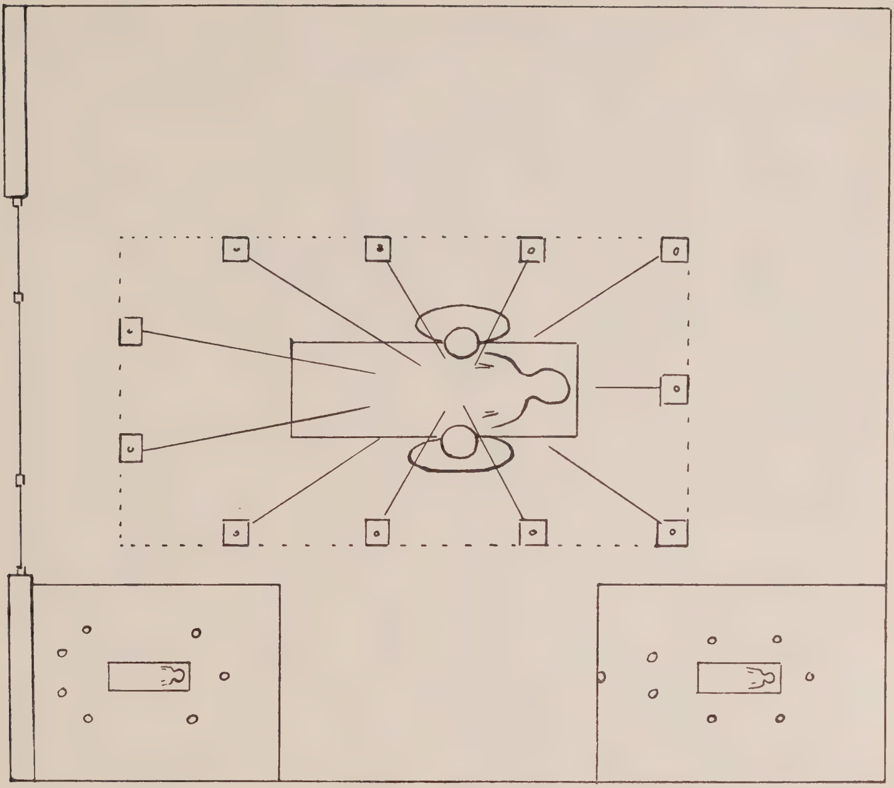


Figure 4—Separate ceiling lights should be parallel to the table. The lighting at the foot should be amplified and preferably low to give penetration for rectal or pelvic operations.

Inset are alternate arrangements for fewer units. Lights at the foot of the table may be several feet down on the wall or window casing.

placed light—light on the white sheets covering the body rather than down in the wound. Here the best way to avoid glare is to use sterilized sheets and drapings that absorb rather than reflect light. White sheets will reflect at least eighty per cent of the light. Gray or green sheets reflect only five to ten per cent of the light. Surgeons are also using satin finished rather than highly polished instruments for the same reason.

Reduction of Shadow:

Much progress has been made. Several so-called "shadowless" lights have been developed and are widely used. Reflecting mirrors, arranged in a large canopy or on arms, may catch the light from a central bulb and focus converging beams onto the body of the patient. With the light beams converging at a wide angle, the heads of the surgeon and his assistant and their hands do not make as intense a

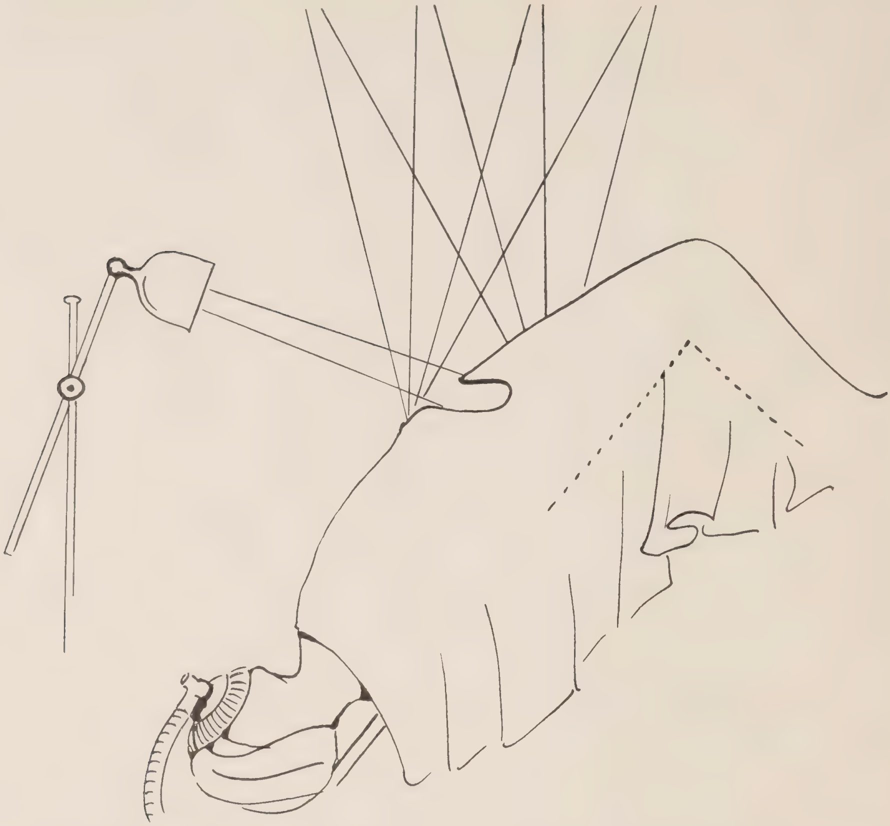


Figure 5—Sometimes the patient must be placed head down for certain pelvic operations. Here deep penetration may be obtained by a portable floor light, a flexible ceiling unit, or a low placed or wall unit where separate ceiling lights are used.

shadow as if the light came from one point. (See Fig. 1). Sometimes there may be a large rectangle or circle of separate lights, either on a suspended frame as formerly, or directly on the ceiling. These are focused on the operating table. In one arrangement a number of lights are placed on the ceiling behind prisms, either all or selected groups being used as desired.

As a matter of fact the term "shadowless" is a misnomer, for most of the shadowless lights will definitely give a shadow under the hands of the surgeon when these are held close to the abdominal wound, which, of course, would be their position during an operation. However, the wider the angle of convergence with which these light rays focus on the patient, the more likely are they to reach under the hands of the surgeon and his assistant with the minimum of shadow. (See Fig. 3). For this reason, individual lights, strategically placed at widely separated areas on the ceil-

ing, and even down the wall at the foot of the table, will give less shadow than most of the single units. (See Fig. 4).

Every hospital should have its operating room equipped with a *portable spotlight.* This is very valuable for many operative details and, being very mobile, can be used to reduce shadow and to concentrate light on any one area in a most effective manner. (See Fig. 5). Moreover every hospital should be prepared for *power shortage.* A mishap in the operating room from power shortage may be prevented by having a portable light equipped with a battery with a trickle charger. Should the main light fail, the operation could be completed with the assistance of this emergency light. The hurricane in New England a little over a year ago left a large number of hospitals filled with injured patients and without any power. For some of them the situation was saved by the portable emergency light in the operating room, but in only a few instances were the hospitals equipped with sufficient auxiliary power to permit them to have lighting in other parts of the hospital.

PATIENTS' ROOMS

The old idea of having a light in the centre of the ceiling is now obsolete. Few things are harder on a patient than to have to lie in bed looking up at a light suspended in the centre of the ceiling. If still used, they should be equipped with an indirect type of lighting, preferably one with an opaque shade below the light so that all or most of the rays are indirect.

In choosing the lighting for the patient's room, several factors should be kept in mind:

1. Avoidance of eye irritation is necessary above all else.
2. There should be a reading light for the patient available both while in bed and while sitting up in a chair.
3. Either these lights or other arrangements should provide sufficient light for the surgeon or nurse to remove sutures, do dressings, etc.
4. Preservation of the "homey" atmosphere is essential.

For the general lighting of the patient's room five or seven f.c. is adequate. For the chair a floor lamp is both effective and decorative and has the added advantage that it can frequently be swung over to the bed to provide the necessary light for the surgeon to do the dressing, if necessary.

The bed lamp should provide about 20 f.c. These lamps are of many types and much care should be taken in their choice. The indirect type of lighting is quite wasteful of power as it is so far from the ceiling that much power must be used to provide 20 f.c. at the level of the patient's book. In those parts of Ontario where 25-cycle power is used, large wattage bulbs are preferable to several smaller bulbs to avoid the flicker which bothers many people, particularly those who are sick.

The lamp should be so designed that it does not shine in the eyes of visitors —a very common observation. There are lights available which are both direct and indirect, having an opening at the bottom for reading controlled, in one model, by a trap door which can be closed sufficiently to keep the

light from the patient's face and which can be closed completely if the patient wishes to sleep. The indirect illumination coming from the top of the light provides general illumination which is sufficient at night and for the use of the nurse walking around the room. Bed lights may be mounted either on the bed or on the wall. Some are detachable for the use of the surgeon. One very fine type of light (in use in the Toronto General Hospital) is on a long, hinged rod which goes down into the bed post. When brought up and bent over, it acts as a surgeon's light.

Night lights are very important in hospital use, both in patients' rooms and in the corridors. Usually they are placed low on the wall and the better night lights have louvres over them which direct the light downwards. Care should be taken that they are not too weak to be of any value nor so placed that they lack usefulness as, for instance, when they are behind the bed. Night lights should never be put in the floor. Cold or heavy objects crack the hot glass. Avoid night lights that cast alarming and grotesque shadows.

In large wards, the ceiling lights should be of an indirect nature, with individual lights on the bed. One of the essential points is to avoid glare from the lights on the beds of other patients.

One of the nicest lights for nurses' stations, waiting rooms and other places where one wants general illumination plus a strong down beam, is one which has indirect illumination going up to the ceiling and a down beam which passes through a grille resembling the cardboard sections in an egg crate. This grille does not appreciably interfere with the light, but it does make it impossible to look up into the lamp and be dazzled by the direct light unless one is directly under it. The use of this grille or baffle has been applied also to individual ceiling lights in the operating room.

Now and then one sees a hospital endeavour to go modern and install vertical frosted glass panels in the corners of rooms and elsewhere. Panel lighting has its place as, for instance, a horizontal panel over an information desk, but when the vertical panels go down the side of a room, as in an operating room, for instance, or even a waiting room, they cause much irritation to the eyes and have no place in a hospital, where the criterion is efficiency and comfort rather than pointless modernity.

Corridors

The old idea of having a long row of overly bright corridor lights has disappeared, thank goodness! The tendency now is to use either the indirect illumination entirely, or, better still, to have the lights recessed up in the ceiling so that there is adequate illumination below the lights but, looking along the corridor, one sees no lights at all. In some hospitals these lights are recessed like portholes in the angles between the ceiling and the wall. Sometimes very striking effects are possible by the use of indirect lighting along the cove. Five to seven f.c. is adequate for corridor lighting. For daytime, the use of glass brick in corridors is meeting with increased favour. We see examples of this in the new mental hospital at St. Thomas

and in the Montreal Convalescent Hospital. Glass brick can be used opposite public rooms such as utility rooms, wash rooms and diet kitchens. This helps to brighten up the corridor considerably.

The Mechanical Properties of Weld Metal Deposited by Various Electrodes

THE investigation reported herein was undertaken as part of the research programme of sub-committee No. 13 on arc welding.

The purpose of the investigation was to obtain a comparison of the mechanical properties of the weld metal deposited by those electrodes which are most frequently used by the manufacturers who build welded equipment for the Commission.

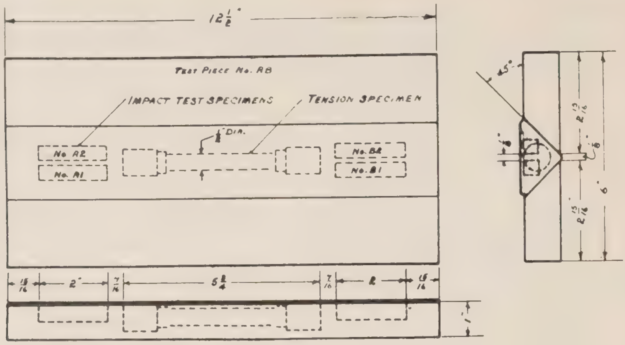
In order to assess the quality of the weld metals deposited by the various electrodes, several different types of tests were employed. These included a determination of the tensile strength, yield point, elongation, reduction of area, Charpy notched-bar impact values and, in the case of a few electrodes, the fatigue limit.

The adoption of this rather comprehensive testing scheme is based on the fact that the service performance of welded metal cannot be appraised on the basis of the results obtained from one type of test. Since welds, as a part of fabricated structures, must in some cases withstand impact or suddenly applied loads, and in other cases resist stresses of a repetitive nature, it is essential to subject weld metal to impact and fatigue tests. Although the figures obtained from these tests are not directly applicable to design problems, they give a definite indication as to whether or not the material is sound, and possesses the qualities required to assure satisfactory performance under dynamic loads. Equally important, from the designer's point of view, are the results obtained from the conventional static test which give a direct measure of the ductility of the weld metal and a value for its yield point, which, if the dynamic properties of the material are satisfactory, may form the basis for the determination of the allowable working stress.

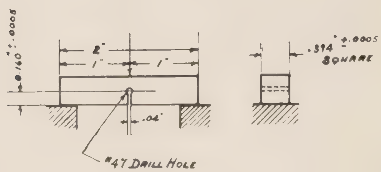
Method of Testing

Two welded test pieces, similar to that shown in Fig. 1, were made up using each of the nine electrodes to be investigated. Each test piece consisted of two mild steel plates 12½ in. by 3 in. by 1 in. chamfered at 45 deg. on one edge. These plates were sep-

Report of the H.E.P.C. Research Sub-Committee No. 13 on Arc Welding as published in the January, 1940, issue of the Journal of the American Welding Society.



Welded Test Piece



Charpy Impact Test Specimen

Fig. 1 - Location of Specimens removed from welded test pieces

arated by ⅛ in., tacked together and welded in the downward position by several passes. Each pass of deposited metal was thoroughly scaled before the next layer of metal was deposited.

All of the electrodes used were $\frac{3}{16}$ in. diameter and were of the shielded arc type.

The test pieces were all made by the same welder.

The welder was instructed to take no special precautions in the preparation of the test pieces, but rather to use the same technique as would be employed in ordinary shop work. As a result of these instructions we believe that a more usable comparison of the electrodes was obtained than if a special technique, which might not be rigidly adhered to under production conditions, had been used. This may explain why, in some cases, the values obtained in the present investigation differ from those which appear in the manufacturer's literature.

One tension and four impact specimens of all weld metal were removed from each of the nine test pieces in the as-welded condition. Six of the corresponding test pieces were stress relieved at 1,100 deg. fahr. for two hours and furnace cooled before removal of the tension and impact weld specimens. The purpose of the tests on the latter specimens was to determine the effect of stress relieving temperatures on the physical prop-

TABLE NO. I

MECHANICAL PROPERTIES OF WELD METALS

Welding Rod Number	Tensile Properties: Ultimate Strength lb. per sq. in.	Tensile Properties: Yield Point lb. per sq. in.	Tensile Properties: Per Cent Elong. 2 in. ga. lg.	Tensile Properties: Per Cent Reduction of area	Impact Number Ft. lb. Charpy Keyhole Notch: 1	2	1	2	Avge.	Endurance Limit lb. per sq. in.	Specific Gravity Avge. of 8 Specimens
AB-W§	65,000	50,000	22.0	38.5	21†	36	15†	32.5	34.2	....	7.816
AB-S§	64,300	48,800	26.0	61.9	34.5	35.5	33.5	29.5	33.2	....	....
CD-W	67,100*	54,900	20.0	32.6	15†	22†	35	32.5	33.7	....	7.836
CD-S	61,800	45,700	32.5	62.0	45	42	42	40	42.2	....	....
EF-W	61,300	49,100	30.0	51.1	24	31	30	30	28.7	....	7.853
EF-S	60,000*	45,400	20.0	31.7	31	34	26	36	31.7	....	....
GH-W	57,800	42,900	33.0	60.8	41	45	43	41	42.5	....	7.857
GH-S	56,900	39,400	39.0	69.6	45	42	37	43	41.7	....	....
IJ-W	58,400	43,800	26.5	40.0	31	33	34	35	33.2	....	7.852
IJ-S	59,000	44,200	38.0	62.9	34	36	36	34	35.0	....	....
KL-W	66,900	52,400	29.0	53.8	30.5	26	28	29	28.4	....	7.838
KL-S	58,500	47,800	31.0	60.5	33	26	36	31	31.5	....	....
MN-W	67,500	52,200	26.3	39.1	33.5	33.5	33.5	34.5	33.7	21,000	7.826
OP-W	60,200	39,900	33.0	62.3	45	44.5	44	43	44.1	20,000‡	7.860
QR-W	73,600*	54,600	15.0	42.5	23	27.5	23	23	24.1	22,000	7.826
Parent Metal	66,000	37,100	36.0	61.5	32	28.5	34	30	31.1	....	....

§W as welded.

§S Stress relieved—two hours at 1,100 deg. fahr., furnace cooled.

*Poor fracture showing a large number of slag inclusions.

†Impact result discarded—slag inclusions located on notch.

‡Fatigue limit indefinite—material appeared to be non-uniform in fatigue resistance.

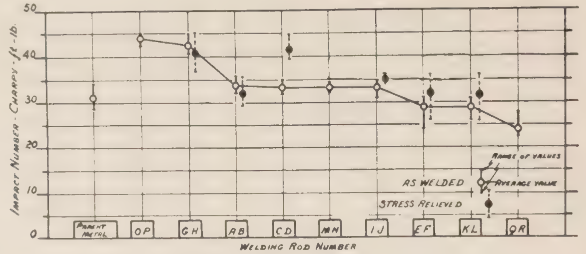


FIG. 2.- COMPARISON OF IMPACT NUMBERS ON ALL WELD METAL

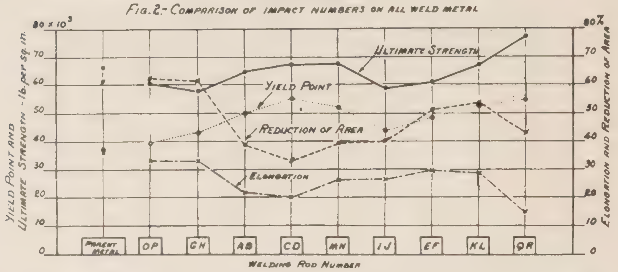


FIG. 3 - COMPARISON OF TENSILE PROPERTIES OF ALL WELD METAL - AS DEPOSITED

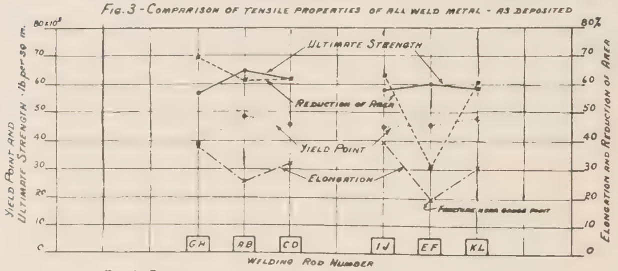


FIG 4 - COMPARISON OF TENSILE PROPERTIES OF ALL WELD METAL - STRESS RELIEVED

erties of the weld metals. The three remaining test pieces were left in the as-welded condition and a sufficient number of all-weld metal fatigue specimens were removed from each to determine the fatigue limit of these materials.

The location in the test pieces from which the tension and impact specimens were removed is illustrated in Fig. 1. Due to the one-inch plate thickness adopted it was possible to obtain standard one-half inch A.S.T.M. tension specimens, full-sized Charpy notched bars and Avery fatigue specimens.

In the case of one pair of test pieces, namely AB-W and AB-S in the as-welded and stress relieved conditions respectively, the cross section of the weld and the adjoining parent metal was surveyed for hardness in an attempt to detect any change in this property which might have occurred in the heat-disturbed area adjacent to the weld deposit.

TEST DATA

A summary of the test data including the specific gravity, ultimate strength, yield point, percentage elongation, percentage reduction of area, and Charpy notched-bar impact number of the deposited weld metal from each electrode is recorded in Table I.

For comparative purposes certain of the data are presented graphically in Fig. 2, Fig. 3 and Fig. 4.

Table I also includes the endurance limits of the weld metals deposited from three of the electrodes. It is anticipated that the fatigue testing of the weld metals from the six remaining rods will be continued during the coming year.

Fig. 6 shows the fractured tension specimen and a typical impact specimen from each test piece. It will be observed from the photograph that the tension specimens OP-W and GH-W show no indication of included foreign matter and broke with a cup-shaped fracture which is indicative of high ductility. The specimens from the remaining test pieces all revealed some evidence of slag inclusions. Specimen QR-W was particularly objectionable in this respect.

Impact Values

In Fig. 2, the weld metals are classified in order of their notched bar impact numbers. The metal deposited from electrodes OP and GH give impact numbers which are some 40 per cent higher than those of the parent metal. The impact numbers of the weld metals deposited by the other electrodes are of the same order as that of the parent metal, with the exception of that obtained from electrode QR, which gave values which were consistently low.

Ductility

In Fig. 3 it will be observed that the elongation and reduction of area of the weld metals deposited from electrodes OP and GH are of the same order as the corresponding values obtained on the parent metal. The ductilities of the weld metals from the other electrodes are somewhat lower than this. Considering the static properties of all of the weld metals which were tested it will be noted that high ultimate strength and yield point are generally accompanied by low ductility. Since, in the case of all the weld metals, the yield point is greater than that of the parent metal, it would appear that nothing is to be gained by increasing the strength of the weld metal above that of the parent metal at a considerable sacrifice in ductility. A good example of this is the weld metal deposited from electrode QR which, although it has a much higher ultimate strength and yield point than the parent metal, is very much less ductile when tested under static or impact loads.

Effect of Stress Relief

A comparison of the data presented in Fig. 3 and Fig. 4 shows that stress relieving of the weld metals, in the majority of cases, lowers the ultimate strength and yield point by a few per cent. This slight decrease in tensile strength, however, is accompanied by a considerable increase in ductility, as revealed by a higher percentage elongation and reduction of area. The stress relieving treatment appeared to have little influence on the impact values of the weld metals.

Hardness Values

The results of the hardness survey across the faces of the as-welded and stress relieved test pieces made with electrode AB, are shown graphically in terms of both the Vickers and Rockwell scales in Fig. 5. It will be

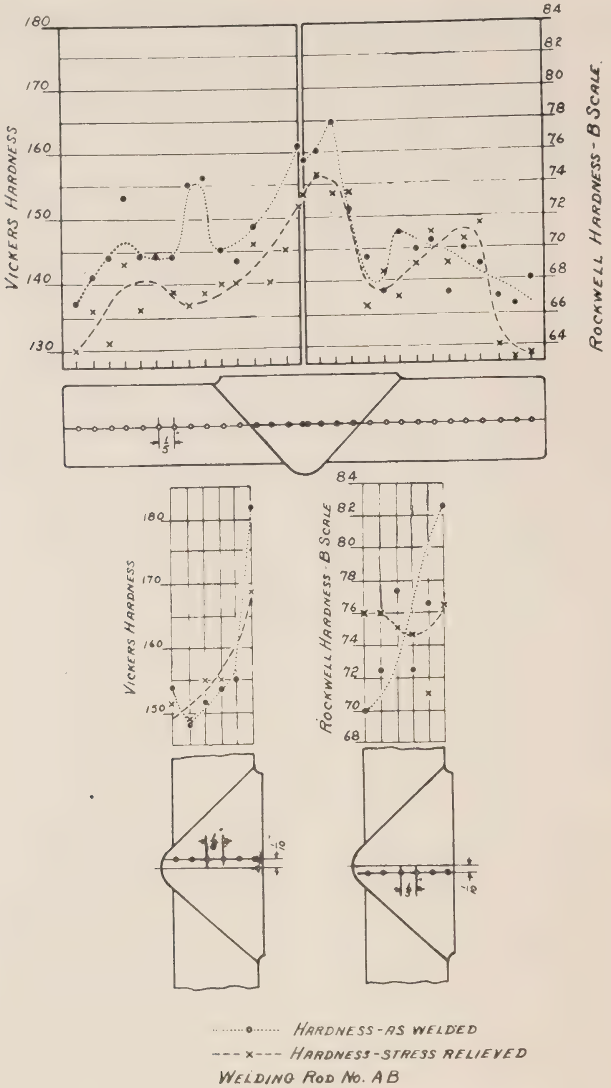


FIG. 5 - HARDNESS VALUES ACROSS WELDED TEST PIECE

observed that there was very little difference in hardness between the deposited weld and the parent metal. No hard spots were found on the line of fusion and in fact the hardness along this line was some 15 points lower on the Vickers scale than the material at the centre of the weld. The metal at the top surface of the weld, which was applied in the last pass and therefore was not subjected to reheating and consequent grain refinement by succeeding passes, was some 40 points harder on the Vickers

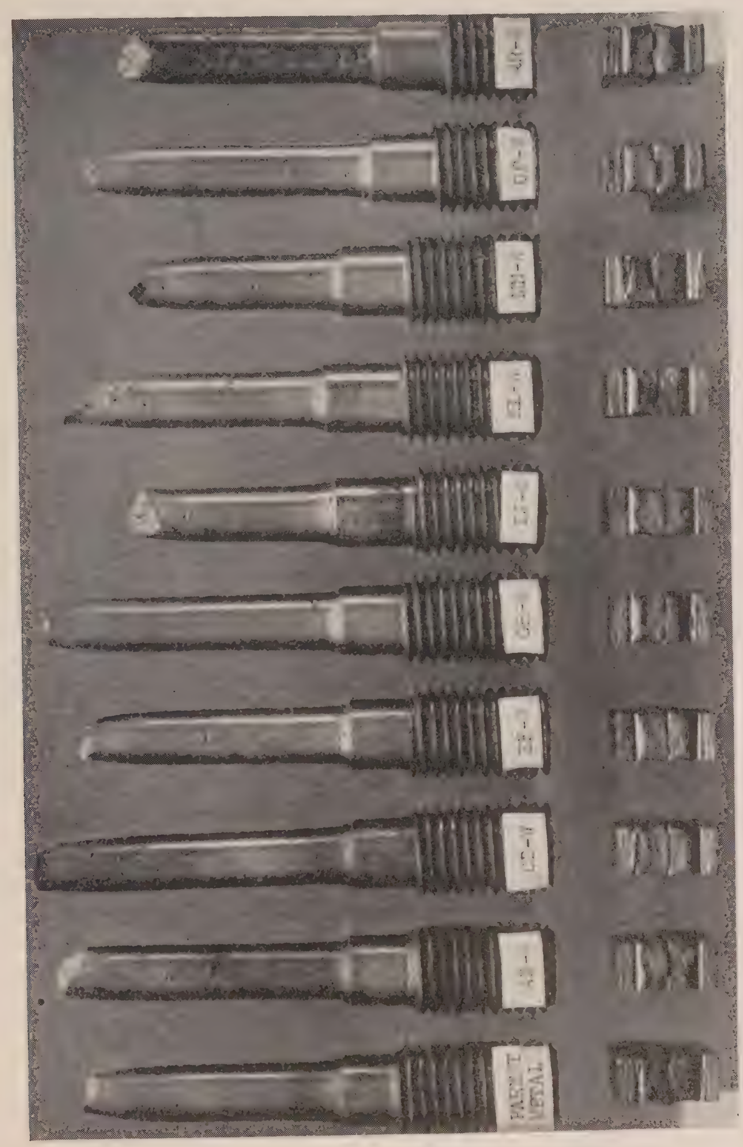


Fig. 6—Fractured tension and impact all-weld specimens.

scale than the parent metal and some 25 points harder than the material at the centre of the weld. The progressive increase in hardness along the centre line, from the bottom to the top of the weld, is a good illustration of the grain refinement effected by multiple bead deposition. Further, it should be noted that stress relief at a temperature of 1,100 deg. fahr. brings about a decrease in hardness of the weld metal which is most pro-

nounced in the very hard layer near the top of the weld.

Conclusions

(1) The weld metals deposited from all of the electrodes which were tested, with one exception, namely QR, gave notched bar impact numbers which were equal to or higher than those obtained on the structural steel plate.

(2) The yield point of the weld metals was higher in every case than the yield point of the parent metal.

(3) Subjecting the weld metals to a stress relieving temperature of 1,100 deg. fahr. brought about a slight diminution in ultimate strength, yield point and hardness, accompanied by a small increase in elongation and reduction of area.

(4) The material deposited by electrodes OP and GH, in the as-welded condition, showed a reduction of area and elongation which was practically equivalent to that of the parent metal. The ductility of the materials deposited from the other electrodes, in the same condition, was, in the majority of cases, considerably lower than that obtained on the parent metal.

(5) The highest impact values and the best static properties were obtained on those weld metals, OP and GH, which had the highest specific gravity and showed no visual evidence of included foreign matter. The weld metals deposited from the other electrodes all revealed the presence of included slag, which may have been caused either by incorrect melting procedure or undesirable characteristics in the coating, which interfere with its complete volatilization. Electrode QR was particularly objectionable in this respect, the deposited metal being dirty, porous, and having a very low specific gravity.

(6) The impact test furnishes a simple method of comparing the quality and homogenity of weld metal. High impact values are always associated with high ductility, as revealed by the elongation and reduction of area in the static test. Consistency in the impact results indicates homogenity of the weld metal, a quality which is very difficult, if not impossible, to assess on the basis of tension tests alone.

(7) The consistency of the results obtained in a series of impact tests on a number of all-weld metal specimens removed from a test piece, such as that used in the present investigation, is a reliable index of uniformity and for this reason could be employed as a qualification test for welders.

(8) In the case of some of the electrodes tested the ultimate strength of the deposited metal, as published in the manufacturer's data, is considerably higher than the values which we obtained. This discrepancy may have resulted from a difference in the plate thickness or size of the electrodes used. It is also possible that the manufacturer's figures were based on test pieces welded under very carefully controlled conditions, whereas the test pieces used in this investigation were prepared under the same conditions as those employed in commercial welding.

Recommendations

The information obtained in the investigation reported above forms

the basis for the following recommendations:

(1) *Electrode Quality Test.*

The insertion of a clause in the Commission's arc welding specification stating that, where deemed necessary, the inspector may require the manufacturer to prepare a welded test piece similar to that shown in Fig. 1, page 24. The impact numbers obtained on all-weld metal Charpy specimens removed from any part of the weld, in the above mentioned test piece, shall be at least 30 ft. lb. If the impact numbers are consistently lower than 30 ft. lb. the electrode shall be considered unsatisfactory and replaced by one which meets the above requirements.

(2) *Qualification of Welders.*

The insertion of a clause in the Commission's arc welding specification stating that, where deemed necessary, the inspector may require a welder to prepare a welded test piece similar to that shown in Fig. 1, page 24. The impact number obtained on all-weld metal Charpy test specimens removed from any part of the weld in the above mentioned test piece shall be at least 30 ft. lb. If the impact numbers are consistently lower than this, or, if, in the inspector's opinion, they are not sufficiently uniform, the welder shall be considered to have failed to meet the qualification test.

ACKNOWLEDGMENTS

The committee wishes to thank the various manufacturers who market welding rod in Canada for their co-operation in furnishing the electrodes, used in this study, free of charge. Acknowledgment is also made of the assistance rendered by Mr. D. G. Watt of the Laboratories of The Hydro-Electric Power Commission of Ontario, who gave valuable help at all stages of the investigation.

Presentation to George Hancock, Galt

There was a very happy gathering at the City Club, Galt, on the evening of December 20th, 1939, the event being the presentation of a silver tea service to George Hancock, Chairman of the Public Utilities Commission, "who for more than thirty years has unselfishly devoted time and energy introducing and establishing for public good, water and electric utilities in the City of Galt."

In 1907 the citizens of Galt had passed the enabling by-law which authorized the proper officials to sign a contract with The Hydro-Electric Power Commission of Ontario for 1,200 h.p., but owing to the serious doubts of some as to the success of the venture there was considerable delay in the completion of the same.

In 1910 F. S. Scott was Chairman of the Fire and Light Committee of the Town Council and Geo. Hancock was a member of his committee and it was largely due to the efforts of these two gentlemen that in that year the contract was signed.

When the construction of the transmission lines was begun J. H. Fryer, who was mentioned by Mr. Scott and who was a Galtonian, was President of the Power Union and turned the first sod for the first transmission lines in Ontario.

George Hancock.

Mr. Scott and Mr. Hancock gave further evidence of their confidence in the scheme as the first two motors driven by Hydro power were turned over in their plants within a few hours of each other.

Owing to the pressure of business and in rendering other public services Mr. Hancock found it necessary to retire from the Council but Mr. Scott continued as Mayor to the end of 1913 and later found a wider field for public service as South Waterloo's representative in the Federal House.

The Electric Department had operated under a Hydro Commission from 1912 and in 1918 Mr. Hancock, whose business ability and good judgment were highly appreciated was induced to accept a position on the Commission and since that time has served continuously.

In 1919 the electors passed a by-law establishing "The Public Utilities Commission of Galt" and since that time the Hydro and Water Depts., have been under the control of this Commission. Owing to the business acumen of Mr. Hancock and his associates these are now in excellent condition, not only from a standpoint of operation but also financially.

The Electric Department has one of the outstanding Hydro buildings of the Province and by March of 1943, will have a plant with a book value of more than $900,000 entirely free of debt while the Water Department has a very efficient plant and an abundant supply of 100 per cent pure spring water and renders a service of a very high order.

This gratifying situation is largely due to the faithful and efficient guidance given by Mr. Hancock and H. O. Hawke, D. W. McCormick, A. E. Willard and the present Mayor, Dr. W. S. McKay, all of whom have for several years worked together on the Commission.

The guests of the Commission at the Banquet and Presentation were the present members of the Commission and their wives, provincial Commissioner J. Albert Smith, Ross Dobbin, Peterborough, H. R. Hatcher, Manager of the Public Utilities Commission, ex-Mayors A. W. Mercer, A. W. Hilborn and R. K. Serviss, ex-Commissioners Geo. E. Fisher, W. A. Dixon and C. R. Widdifield, G. C. Parker, District Engineer of the provincial Commission, and all the members of the staffs of both departments.

The whole affair was conducted as a surprise to Mr. Hancock. It was a most enjoyable family party.

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Norfolk Transformer Station

A New Outlet for Supply to Simcoe Area

By G. E. Kewin, System Planning Engineer,
Electrical Engineering Dept., H.E.P.C. of Ont.

NORFOLK transformer station, located at the crossing of the Windham road and the Lake Erie and Northern Railroad about two miles north of Simcoe, Ontario, was placed in service on the Niagara system on January 28th, 1940 and is a departure in a number of design features from 110 kv. stations now in service on this system. It is the purpose of this article to describe some of these features and to discuss briefly some of the problems considered before the station was actually built.

The district served from the new station covers most of Norfolk county and includes the municipalities of Simcoe, Port Dover and Delhi, as well as a number of rural power districts. These municipalities were formerly supplied over a 26 kv. circuit out of Brant transformer station. The length of the circuit (28 miles to Simcoe and 45 miles to St. Williams) and the rapid growth of the loads made improvements in supply to these points imperative. The whole question of supply to the Simcoe and adjoining areas was, therefore, made the subject of a comprehensive study in which the influence of the loads in the areas immediately east and west of Simcoe was included.

A measure of improvement for a short period could have been made in the supply to some of the municipalities by various less comprehensive expedients. However, a study of the estimated load growth indicated that these would have been temporary only and it appeared that, based on the probable load growth over a period of five years, a new source of supply from the 110 kv. system was the best solution, the only matter in doubt being the economy of this station for loads of 7,000 to 10,000 h.p.

CONTENTS

Vol. XXVII **No. 2**
February, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

A study of conditions of supply to the whole area from Hagersville on the east to Tillsonburg on the west indicated that taking into account annual costs for transformation and distribution there was little to choose in the long run between providing the necessary transformation in one or two 110 kv. stations. The supply to Hagersville area had recently been materially improved by changing the feeder voltage to 26 kv. It was apparent that the supply to the Tillsonburg area now served from Woodstock transformer station at 13 kv. could be dealt with as a separate problem. Design of a station to serve the Simcoe area only was, therefore, proceeded with as requiring a minimum of immediate capital expenditure both for station and feeders.

TYPE AND LOCATION OF STATION

As the load in the district to be supplied from the new station was in the order of 5,000 to 6,000 h.p. a low cost station was imperative in order that transformation costs might be kept to within the same level as those at existing stations. Such a type of station had been developed in the mining areas of the province and several years' experience has indicated its suitability to other applications. The experience so gained is reflected in the station as now constructed. The low cost station, although simple in design, has advanced features such as on-load voltage control and automatic feeder breaker reclosure. Automatic features are provided in this design such that full time operating attendance is avoided though a patrolman will be located there so as to be available for such line switching or other duties as may be infrequently required. In addition to the low cost features of the design, therefore, the further application of the necessary forms of control will effect a substantial saving in operating attendance costs.

DETAILS OF 110 KV. LINE

The station is supplied by a wood pole 110 kv. line tapped off the trunk lines between Queenston generating station and St. Thomas transformer station. The line has been specially designed to meet the requirements of a low capacity circuit of minimum cost which will at the same time be

Fig. 1—Line to Norfolk station showing typical towers.

highly reliable. It is of twin pole construction with interior "X" bracing of wood as against the more usual external wire guys. In order to minimize the danger of a completely wrecked cross arm due to a lightning stroke two 2 by 10 inch plank cross arms are used instead of the usual 6 by 8 inch arm. There are twelve structures per mile, the average span being 440 feet.

The insulation provided follows the Commission's standard for 110 kv. wood pole lines; seven 5 inch units in suspension and ten units in strain.

The electrical load on the conductor is relatively low, resulting in an economical conductor size that would be mechanically weak if standard conductor were specified. Therefore, a special conductor size was used having twelve aluminum strands of 190,800 cir. mils total section with a core of seven strands of steel, each 0.1261 inch diameter. The breaking weight of this conductor is 17,720 pounds. The maximum loading under ½ inch ice and 8 pound wind is estimated to be 3,400 pounds, which gives a high factor of safety under the most unfavorable conditions. To obtain better lightning protection and greater clearance between ground wire and line conductors the poles are extended 5 feet higher than usual in this class of line. One ground cable is used but the construction is such that if necessary a second cable can be erected at comparatively little expense. Every structure is grounded by use of a down lead to the bottom of the pole, where it is "pancaked" to obtain lower resistance to ground.

The complete structure, therefore, has both a larger electrical as well as mechanical factor of safety than is provided by some earlier forms of design. Fig. 1 shows a typical tower with "X" bracing and extended pole tops, one of which carries the single ground wire.

Two gang-operated line switches are provided at the junction point of this line and the trunk lines. With

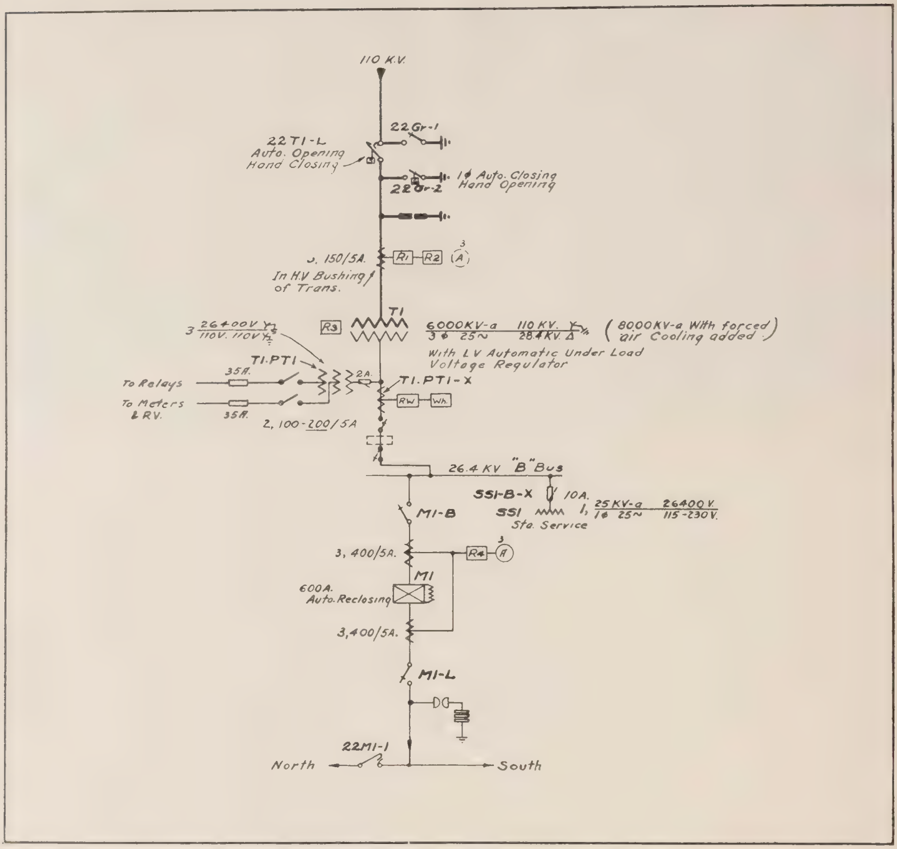


Fig. 2—Norfolk station diagram.

this arrangement the line can be connected to either of the trunk lines, giving increased service security and facilities for line maintenance.

Details of Transformer Station

Fig. 2 shows a single line diagram for the station with the single transformer bank at present installed. Fig. 3 is a view of the station from the low voltage side, while Fig. 4 shows the transformer during erection, with part of the steel structure, and connection to the 110 kv. suspended bus.

Connection to the 110 kv. line is made through a gang-operated horn gap switch, rated 138 kv., 600 amperes, and arranged for automatic opening and manual closing. There is also a 3 pole gang and manually operated grounding switch.

A single-pole, single-throw, 138 kv., 200 amperes automatic closing ground switch is used to isolate the station if required, due to trouble developing in the transformer or associated equipment. In such case, the switch grounds a single phase of the transmission line causing it to trip at its terminals.

The transformer is rated 6,000

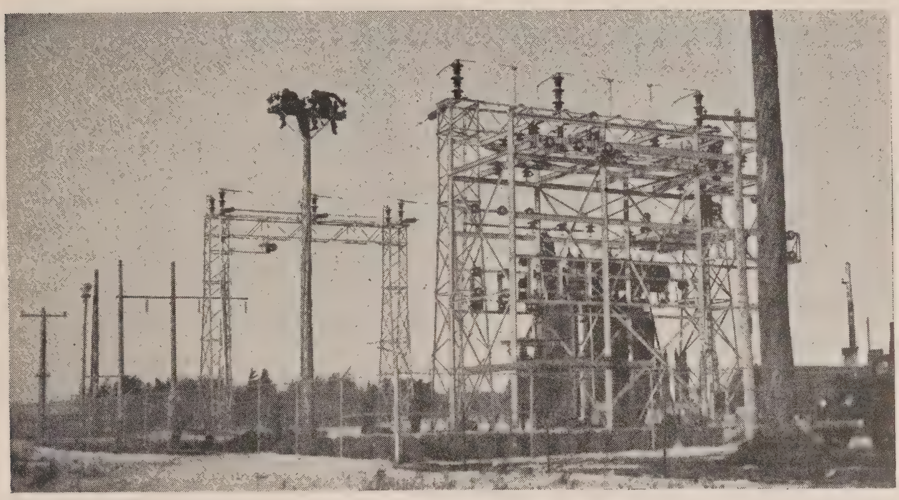


Fig. 3—The station from the low voltage side.

kv-a., 3-phase, 25-cycle, 110,000/28,-400 volt, o.i.s.c., outdoor type, with provision made for forced air cooling to give a rating under this condition of 8,000 kv-a.

The transformer is also equipped with an on-load ratio adjuster for automatic regulation on the 28,400 volt side in seventeen equal steps between 25,560 volts and 31,240 volts. Voltage regulation is controlled with a contact making voltmeter and line drop compensator. The latter device allows for automatic control of voltage with change of load at a predetermined load centre on the 26 kv. feeders remote from the station. The regulator permits independent regulation of voltage at the distributing stations supplied from this station, in spite of the fact that the Norfolk station is supplied from a tap to a long trunk line in which a rather wide daily voltage variation normally occurs.

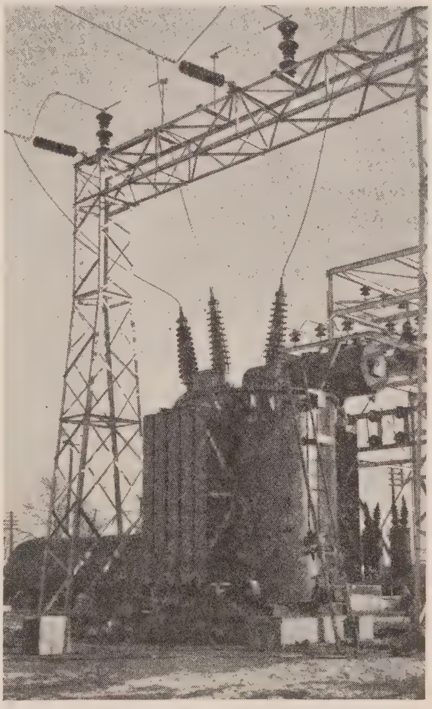


Fig. 4—Transformer station during erection, showing part of the steel structure and connection to the 110 kv. suspended bus.

There is at present a single 26 kv. feeder position supplied through a single, 600 ampere, 34.5 kv. oil circuit breaker, electrically operated, and equipped with automatic reclosing relays to re-energize the feeder once after tripping automatically, followed by lockout if a faulty condition is again indicated. It is our experience that the majority of feeder faults are of a temporary nature such as lightning flashovers and service can be restored with one reclosure. If the fault is not clear after the first trial, it is in practically all cases of a permanent nature, so there is little advantage in further attempts at automatic reclosure. We have, therefore, provided the recloser of simple "single-shot" type.

The single feeder leaving the station divides just outside, one branch leading north to tap the present 26 kv. line from Waterford to Delhi. The second branch leads south to Simcoe. The north branch can be isolated by means of a 600 ampere, 34.5 kv. gang-operated disconnecting switch.

Station service is provided through a 25 kv-a., single phase, 25 cycle, 26,400/115-230 volt outdoor, o.i.s.c. service transformer. A 54-cell, 110 volt tripping storage battery is also provided; it is charged by means of a radio-tube type 110 volt trickle charger.

The station switchboard and its equipment, as well as the battery, is housed in a small fire-resisting building.

The 138 kv. and 26.4 kv. switching equipment is supported on steel structures and concrete foundations.

A patrolman's house is located on the station site, as well as a combined garage, storehouse and workshop.

This station was completely designed by the Commission's Electrical Engineering Department and erected by the Commission's Construction Department. Following a trial period, during which adjustment of the step regulator will be made to obtain best overall performance and good average voltage at the respective distributing stations, it is anticipated that service to these stations will be noticeably improved. The stations remaining on that part of the 26 kv. feeder still supplied from Brant transformer station will also benefit by this new installation, by the fact that it will now be much less heavily loaded, and not subject to the interruptions associated with its former greater length.

Hydro and the War

By Dr. T. H. Hogg, Chairman
The Hydro-Electric Power Commission of Ontario

TO-DAY as you may rightfully expect my remarks will deal with one phase or another of Hydro as it is affected by this war, and of the service we believe Hydro can render to the cause of ultimate victory. That Hydro will do its best for our common cause goes without saying. You would not be satisfied with less.

Canada has been assigned a tremendously important role in the Empire's war effort. We have already seen private funds subscribed, we shall see industry mobilized, we shall see the flying strength of the Empire centred within our borders, as the first steps in the course we are to pursue. We see new factory buildings rise and we ask ourselves whether they are the forerunners in a vast expansion of industrial activity. Hydro's policy must be abreast of all this. Hydro's plans must be so formed as to meet any future contingency.

We may be sure, I think, that the success of this war will be largely dependent on the wholehearted co-operation of industry. Machines will play a vastly more important part than ever before. It is a mechanized army that fights this war. The tank and the aeroplane, modern transport of all sorts, new and more costly weapons, these are the realities of to-day. Everywhere there are new and expanding needs for mechanization. I think I am right in saying that a battalion of 1,000 men, in the last war was equipped with only two machine guns. In this war a battalion of 700 men will carry fifty. It is the hope of every one of us, I am sure, that machines may this time take some of the punishment which in the last was borne by flesh and blood.

Canada has a very definite part in all this. It is not represented only by an Expeditionary force. Behind the army in the field there must be mobilized a vastly greater army of technicians and workers. It is our part to be an efficient machine shop, a storehouse on which our Empire may call, to meet any need that may arise. Surely it must not be again, as unfortunately it was in the last war, that men were called upon to die because industry at home was inadequate to serve their needs.

During the first World War our own Canadian divisions were largely armed, supplied and trained overseas. To-day we are trying to equip them in every detail of their needs. We are to be the training ground for the vast air effort of the Empire. Men from every quarter are converging here to learn the art of aerial warfare. Much more than was the case in the last war, we are to be industrially mobilized in this.

It is a far stronger Canada that stands to-day by the side of Britain

Address to the Ontario Municipal Electric Association and the Association of Municipal Electrical Utilities at Toronto, February 6, 1940.

and France than was the case in 1914. Our exporting capacity is more than twice as great; our manufacturing production has approximately tripled; our mining output is many times greater; large increases have also occurred in agricultural and forestry production. But nowhere is there greater evidence of growth than in refined base metals. In 1913 Canada was producing refined base metals at a rate of 68 tons per day; to-day Canada produces, daily, more than 2,000 tons; over thirty times as much as in 1913.

Our Resources To-day

To those of us who know the extent of industry's dependence upon power, the question at once arises: How do Canada's developed power resources to-day compare with her resources in 1914-1918? As 98 per cent of our central electric stations output is derived from water power, the figures of hydraulic turbine horsepower will serve as a rough guide to our growth in power supplies.

The total hydraulic horsepower installed in Canada in 1914 was a little less than two million, and by 1918, under the pressure of war demand, it had grown to only two and one-third million. To-day it is more than eight and one-third million horsepower, so that we have now available in Canada more than four times the mechanical and electrical power that we had in 1914, and three and one-half times as much as was available at the close of the last war.

Now, in regard to the Commission's own power resources. We have at present available in our own plants and in purchased power, almost as much as was available in the whole of Canada at the close of the last war, or two and one-quarter million horsepower.

That is a very sharp advance over the 101,400 horsepower that the Commission had available in 1914: although Hydro now operates a number of plants which in 1914 were in private hands.

In 1914 the average consumption of energy by domestic users, served by Hydro municipalities, was about 21 kilowatt-hours per month. To-day the average is 165 kilowatt-hours per month, virtually eight times as much. At the same time, commercial lighting has increased to five times what it was in 1914.

During the interval between the last war and this, the increase in industrial use of electricity has been enormous. Thousands of factories have been established, technical processes have been developed, personnel has been trained, and a strong broad industrial base has been laid. On this broad base Ontario industry is capable of rapid expansion. But for the existence of this industrial foundation, the production of munitions and supplies vital for the war, in quantities that would have any significant effect upon the outcome, would be impossible.

System Resources

Looking back at the last war, you will recall that notwithstanding the Commission's utmost efforts, a power shortage on the Niagara system occurred during 1917 and 1918. That shortage threatened to handicap vital industry at a time when the need for power was tragically urgent. With

this in mind let us take stock of the Niagara system resources at the present time.

The outlook has changed materially since February, 1938, when my comments on our settlement with the Quebec power companies were given to you. Who would have thought then, that we would to-day seriously question the adequacy of our Niagara system resources to meet the demands upon them beyond the early fall of 1942.

In December, 1939, our Niagara system primary load exceeded the peak of the previous year by 150,000 horsepower, a growth of 13 per cent. After allowing a minimum amount for needed reserves, the appropriate capacity for that December, 1939, demand exceeded the figure which in February, 1938, I indicated as the "probable best provision" for it by 23,000 horsepower.

It is true that our present resources exceed the so called "probable best provision" and exceed our actual requirements, even after allowing for reserves, by some 97,000 horsepower. But, as against this, the total amounts of power scheduled for delivery under our Quebec contracts, including the last block of 20,000 horsepower due in November, 1944, is only 140,000 horsepower. This total amount of undelivered power is less than the growth that took place last year.

A load increase of 10 per cent per annum for two years over the load of December last, would mean that every resource of our Niagara system, including the last block of Quebec power not due until 1944 would be needed to meet the demand for primary power as of December, 1941, while providing only a very moderate reserve for safety.

Most of you will remember that for a period of eighteen years prior to the thirties, load increases of 10 per cent per annum were the order of the day. That such increases cannot go on forever no one doubts, but if what we hear about industrial expansion during this war means anything, load increases of 10 per cent per annum would seem to be quite moderate while war lasts.

Loads on the Eastern Ontario system and Georgian Bay system approximated the capacities available on these systems in December, 1939. Should last year's growth of 10 per cent continue, some 40,000 horsepower, exclusive of reserves, will be required to meet demands in 1941. Transfer facilities will be available through which this growth may be supplied from Niagara system temporarily. In December, 1941, the combinded growth of these three southern Ontario systems will probably exhaust all the growth resources of the Niagara system, leaving no reserves whatever.

On the Thunder Bay system present capacity is only sufficient to meet new demands that are now virtually in sight. The rapid growth in the northern mining loads will soon exhaust present capacity, especially in the Patricia-St. Joseph district even with the new unit recently installed at the Ear Falls generating station. In the Abitibi, Sudbury and Nipissing districts present capacity would seem to be adequate to meet load growth for the next two years.

Post-War Industry

There is one more source of possible power demand that I would like to call to your attention. It is not exactly a war demand, but rather a concomitant of war. I mean the influx of industries from countries which have already been absorbed or are now under the direct threat of war. These industries are coming here asking for an opportunity to carry on their business free from the ever-recurring threat of war. We must serve these industries and make them a part of our growing industrial life, for it is greatly in our interest to do so.

There are industries from within our own Empire and particularly from within the United Kingdom, which are finding the constant threat from the air, the submarine menace, the scarcity of shipping, almost overwhelming obstacles to the successful conduct of their business. They too are seeking a haven here, and it is surely laid upon us who are faced with few dangers that we should assure these industries, not only a welcome, but conditions under which they can operate for their own benefit and ours.

No more effective means of cushioning the shock of ultimate cessation of war business can be found than the influx of post-war industry; certainly no belligerent country can look forward with comparable expectation to industrial immigration as we can in Canada. Let us not lose sight of the effect of this upon our post-war demand for power. It will certainly have a tendency to offset the shrinkage in war demand and should be comforting to those who fear a possible excess of power resources in days to come.

No Reduction in Rates

Although last year's financial results are on the whole very satisfactory and this year promises to be even more so, I have no time to-day for any detailed review of financial operations. The annual adjustment of costs for the past fiscal year, as it approaches the final stages, shows an excellent position for the Eastern Ontario, Georgian Bay and Thunder Bay systems. The Niagara system too is very satisfactory; present indication is that besides meeting all current costs for operation and interest, it will be possible to provide out of revenues, for full sinking fund requirements, full renewals reserve requirements, and a substantial provision for contingencies reserve as well. This year, ending October 31, 1940, the amount of additional power purchased under the Quebec agreements is small and the effect of a more complete use of our total resources for primary sales will be evident. Therefore, we may look for an even better financial showing.

With this in view I wish to say one word about rates. Do not expect any general reduction in rates on any system until after the war. The uncertainties of the demands that may be imposed by the war, but more especially the uncertainties of the aftermath of war point to only one sane course. Any excess funds that under ordinary circumstances might be returned to municipalities either by way of large thirteenth credit adjustments, or by reductions of interim rates, must be conserved. When we

have no means of knowing what may face us with regard to future interest rates and future power demands and when we consider the magnitude of capital expenditures that may have to be made in the near future, it is essential for the Commission to build up reserves and at the same time to finance capital extensions as far as possible through its own resources. This policy of postponing possible reductions in rates and building up reserves is the only policy consistent with ordinary business prudence.

You have all received notices regarding the annual adjustment of the cost of power and the yearly closing of electric utility accounts. These were given by the Secretary of the Commission under date of January 29, 1940. Under the plan described therein Municipal Electric Utilities are given the option to continue to treat the annual adjustment account as heretofore, or, if they prefer, to include the debit or credit involved in their business for the next succeeding year. Moreover, if they wish to do so, they may now distribute the payment of any thirteenth annual adjustments debits over the remaining months of the Commission's fiscal year.

The St. Lawrence Development

For more than two score years the development of the St. Lawrence river for navigation and power has been a dream in the minds of the people of the United States and Canada. Several times interest and activity has been stirred to a high pitch.

In 1932 the advocates of development appeared to be on the verge of success. After exhaustive study by national engineering bodies and lengthy negotiations between representatives of the governments of the two countries a treaty designed to provide the basis for the undertaking was signed.

The treaty provided for the orderly improvement of the river sections of the waterway from the head of the Great Lakes to Montreal harbour. It also provided for the immediate development of the water power in the international rapids section of the St. Lawrence river as an integral part of the comprehensive project; this international rapids development was to have been a joint undertaking for navigation and power.

Canada and Ontario entered into an agreement at this time under which the power on the Canadian side was to have been developed by the Province.

When submitted to the United States Senate the 1932 treaty failed to receive ratification. In consequence it was never formally presented to the Parliament of Canada nor was the Canada-Ontario agreement submitted to the Provincial Legislature.

During 1937 discussion of the diversion of Northern waters into the Great Lakes through Long Lac and the Ogoki river, and the exclusive use by Canada of waters so diverted all down the international boundary, focussed considerable attention upon the need for an international arrangement under which these international waters could be more effectively used to meet the needs in each country.

In May, 1938, Mr. Cordell Hull, Secretary of State for the United States put forward a comprehensive

proposal for the settlement of problems on the entire Great Lakes-St. Lawrence waterways system. Mr. Hull submitted a draft treaty which provided as before, for the construction of a deep waterway from lake Superior to Montreal harbour and as before for the development of power in the international rapids section of the St. Lawrence river.

This treaty also provided for the construction of remedial works for the protection of the scenic beauty of Niagara falls and the development of additional power from the Niagara river. This provision, which makes additional Niagara power development contingent upon the St. Lawrence Waterways agreement, is of significance.

Toward the latter part of 1939 discussion of the Hull proposals was opened between representatives of Canada and Ontario and early in January 1940 negotiations between Canada and the United States commenced. It is my understanding that Canada and the United States are in substantial agreement and that the way to signing a new treaty is open.

The general scheme of development chosen by those responsible as the basis for the treaty now under negotiation was selected with a view to avoiding features which in 1934 aroused objections in the United States Senate and may have been partly responsible for the defeat of the measure when submitted to that body. From an engineering standpoint the development plans are perfectly sound. They also have the advantage of being materially lower in cost than those that were incorporated into the 1932 treaty, while at the same time affording full protection for all the interests in the various sections of the St. Lawrence river.

Under the Hull draft treaty the United States assumes nearly all of the cost of the joint works and the works solely for navigation in the international section of the river. The United States does this in recognition of expenditures already made by Canada at other points—for example, on the Welland canal linking lake Erie and lake Ontario—and with a view to effecting a more equal international division of the total cost of the project from the head of navigation to the Montreal harbour.

In his letter to the Government of Canada, Mr. Cordell Hull summarized the provisions in the tentative draft treaty in the following words:

"In brief, the proposed treaty would:

(a) enable the United States to go forward immediately with the International Rapids Section link in the proposed St. Lawrence deep waterway and the incidental power development;

(b) defer Canada's responsibility for completing its share of the waterway for a sufficient time to assure the readiness of the Ontario power market to absorb its share of the power;

(c) provide for an international commission to develop plans and advise the two Governments in a program to promote the most advantageous use of the entire Great Lakes-St. Lawrence resource;

(d) assure the immediate undertaking under the supervision of this commission of the proposed remedial works to preserve the scenic beauty of Niagara Falls;

(e) permit the Province of Ontario to go forward with its plans for diversions from the Albany River basin into the Great Lakes and utilize such additional water for power at Niagara;

(f) make available considerable additional Niagara power to each country for development at will; and

(g) enable the proposed commission to proceed immediately with the preparation of comprehensive plans for more efficient use of the resources of the Niagara River."

The question of whether the international section should be developed in one or two stages has been the subject of much expert discussion and has also aroused considerable public interest. It is a question of such magnitude that it must be settled very largely upon engineering and economic grounds. Of necessity the choice must take into account a valuation of the combined influences of capital cost and operating expense, and the final choice must reflect the best combination between these two having due regard for the quality and performance of the works and for historical and sentimental values.

Owing to the fact that Canada has already expended much larger sums than the United States on existing works which are essential units of a deep waterway from lake Superior to Montreal harbour, Canada was to be relieved, under the 1932 Treaty, of the cost of all works common to the navigation and power and of the major part of the works strictly for navigation in the international section. Canada's contribution to the completed project consisted of works largely in the Province of Quebec. After allowing for fixed contributions which Ontario undertook to make to Canada in return for the enjoyment of joint works and power works, Canada's net cost for the completion of the deep waterway was to have been something in the order of 45 million dollars.

Assuming that the division of costs under the new agreement would not be materially different from the old, this cost of 45 million dollars may be taken to represent Canada's out-of-pocket expense under the new agreement. In the event of an agreement now, the works in Quebec need not be undertaken until after the end of the war.

The significance of the foregoing will be apparent at a later stage in this discussion.

I think it is quite evident that this development could hardly be classed as a war measure, for even if it were undertaken to-morrow, it would be five years at least before it could become of use. There may be many people who would question the wisdom of inaugurating so great an undertaking at this time. That viewpoint is understandable, but there are circumstances under which action must be taken at the time when it is possible to take it. Where there are four parties to any agreement and

a fifth that must be considered, one of the major difficulties is securing a united opinion. This project that involves Canada and the United States, New York State and the Provinc of Ontario as active participants, (with Quebec as an indirectly interested one) has been fraught with all sorts of difficulties political and otherwise. It has come to a stage now where there must be some measure of compromise. Where three of the four participants are ready, and where the fourth believes in the soundness of the project, the occasion may be said to be opportune. If it were not for the war we should scarcely hesitate; if we wait, other even more formidable obstacles may arise.

I hope what I have said has made reasonably clear the ramifications of the St. Lawrence project and the Commission's direct and indirect interest in it. Now a word about the negotiations at Ottawa and Washington. From news accounts of the negotiations, my part in them might easily be misunderstood, yet it is easy to explain.

I believe the St. Lawrence navigation and power project to be sound. I believe also that if an expenditure of approximately $45,000,000 by Canada were needed to remove an obstruction in the way of 35 ft. navigation from Quebec to Montreal, it would be forthcoming overnight. I believe too that Canada need have no greater hesitation about making a like expenditure to bring 27 ft. navigation from Montreal to Port Arthur and Fort William. My contention is borne out by the actual expenditure on the St. Lawrence ship channel between Quebec and Montreal. Since 1925 at least $45,000,000 has been spent on this channel in addition to $26,000,000 previously expended.

But my primary and official concern is with the power aspect of this question. No doubt you realize that the Commission is not as yet dependent upon the early development of the St. Lawrence for its additional power supplies, even though additional quickly-available Niagara power and the use of water from the Ogoki and Long Lac diversions are linked with it.

What we must know, and must know soon, is whether or not the St. Lawrence is to go ahead at once. Our plans for the next five or six years will be very different in the one case from the other, and we must have a decision that will enable those plans to be laid within a very few months. This is the crux of the whole situation so far as I and my colleagues are concerned.

My part in the negotiations has been to furnish engineering information, to help explore possible engineering compromises essential to agreement, and to help reconcile divergent engineering and economic views. Any pressure from me has been for a decision as to whether or not to proceed: never for a particular decision, either affirmative or negative. Nevertheless I repeat that I consider the St. Lawrence project sound having regard to the relatively small capital expenditure required on the part of Canada.

MORE BOUNTIFUL FUTURE

I know that there are those who have quite openly stated that this war will be the end of the civilization that we have known. For myself, I cannot hold any such view. Dreadful it may be—destructive it may be—a terrifying drain on resources that might have been used to promote a lasting human good; but it is not the end. I do not believe that this Nation and this Empire that entered this war with hands that are clean, can be destroyed by any power in the world.

And so I look forward, even to a material expansion in the system with which I am associated, without any feeling of dread or uncertainty.

The history of Canada in the quarter century since the World War burst upon us, has been in the main a story of a progress to an established nationhood. We who were almost unknown in those days have become the fifth great trading nation of the world. From that tragic August day of 1914 the path we have followed has been one of steady progress.

Let me quote some figures which speak of the progress of these years:

Gold output in 1914 was 800,000 ounces. In 1938 it was 4,700,000 ounces.

Petroleum output in 1914 was 200,000 barrels. In 1938 it was 7,000,000 barrels.

Sugar production in those years rose from 70,000,000 pounds to 1,070,000,000.

There were 25,000 automobile units produced where last year we produced 175,000 units.

Mineral production has risen from a value of $144,000,000 to $444,000,000. The capital in industry has more than doubled.

Our manufactured products are to-day almost three times as great as they were in 1914.

Our balance of trade has shown a spectacular change. In 1914 we exported $400,000,000 worth of goods, and we imported $600,000,000. In 1938 we had increased our imports by only $58,000,000 but our exports had reached $927,000,000, turning the trade balance sharply in our favour.

In the face of these facts we would be men of little faith if we did not look ahead and prepare for a more bountiful future. In such a future the demands made upon industry will be vastly enlarged, and industry will make new demands on power. There will be a growing demand, too, for electrical energy to release us from drudgery.

WEIGHTY DECISIONS

Let us review the situation we now face as it affects our immediate responsibilities. On the Niagara system we have in hand resources sufficient to protect our growing demand for about two years. On other systems we have a less generous margin, in fact on some systems our margin of reserve is such that early action is necessary. Even so adequate provisions can be made in all cases.

That it is our job to meet the demands of war industry, whatever they may be, I know you will agree. Yet future needs were never more difficult to estimate. The reasonably

possible maximum and minimum demands never seemed so far apart. One of the most vital questions—how long will the war last—is as uncertain and impossible to answer as ever.

In this maze of uncertainties and indeterminates, weighty decisions must soon be made: decisions that are important for industry, that may make or mar Ontario's war effort, that have far-reaching consequences for Hydro. I am not now in a position to deal specifically with these decisions. In any case, the responsibility for them rests upon this Commission and we are prepared to accept it.

Since there is so little hope of hitting the mark squarely by making perfect provisions as to quantity and time of maturity, suppose we examine the consequences of missing the mark on one side or the other; in other words, the consequences of under or over-supply.

Over-supply, as we well know, is undesirable from a financial viewpoint. It costs money. But cost is measured in dollars and financially Hydro is very strong. The loss of a great many dollars would not be crucial.

Under-supply, as we know equally well, is a different story. It too, would have a dollar effect, directly upon industry, but an effect that, by comparison with other effects, we would count as insignificant. The real cost of under-supply would be measured in terms of those things in life that we hold most dear. The loss of young human lives and the weakening of our war effort with all the frightful consequences it might entail.

Between such courses I do not think any one of us would hesitate. Hydro must and will prepare to meet the demands that may be made upon it for the furtherance of this war. Nor can we wait until the demand develops. We must plan and move *in advance*. Happily for us I see no reason to believe that this policy will even faintly endanger the soundness of our enterprise.

But I want you to keep in mind that we cannot escape one risk or the other. No course open to us is perfectly safe.

These years will pass. Time will tell whether our course was near or wide of the mark. I want to say now that these decisions we must soon make should then be reviewed in the light of the urgency of the moment in which they were made; that they should be considered in the light of what we know now, not upon facts which later may be patent to us but which now we can neither know nor foresee.

We are told that our industries are to be organized on an unprecedented scale. We are told that in a long war Canada may become the arsenal of the Empire. To what extent this may be true, I cannot say. But I can tell you that Canada cannot possibly play such a part unless she can supply huge additional quantities of power.

Public Relations

By E. V. Buchanan, General Manager
The Public Utilities Commission, London, Ontario

"PUBLIC Relations" is a hackneyed, high-sounding phrase but there seems to be no better one to express the idea to be discussed. In big business there is to be seen, unfortunately, much unethical propaganda worked out by gentlemen called public relations counsellors, their title being so often a pompous disguise for catch-as-catch-can press agents. The matter in hand, however, at once excludes all the persuasive, devious and artful words and acts of such people. It is not a scheme for the justification of improper practices; it is concerned solely with the honest interpretation and moulding of public opinion with respect to Hydro.

There is probably nothing set forth in this address which is new, but if emphatic reiteration is of any value, then some good may be done the cause of Hydro.

First, let the question be asked, "What is this Hydro enterprise?" Sir Adam Beck and his associates, when Hydro was conceived, did not think so much of kilowatt-hours delivered all over this province at prices lower than those, then charged by private companies, but rather did the founders have a vision of the potential energy of our natural resources transformed into better living conditions, comfort and convenience in the home, the office, the farm and the factory, thus the motto on the crest of The Hydro Electric Power Commission of Ontario, "Dona naturae pro populo sunt."

It is well that to-day we should keep this vision clearly before us because numerous are the moralists who have attacked this machine age as the source of all the ills we bear. But is it not that these folks, who complain of man's progress, confuse means with ends? The machine is not an end; it is a tool.

The Hydro system is only the tool, but if the tool is to accomplish its purpose it must be kept in good working condition, and thus the first step in rendering a worthwhile service to produce good and satisfactory results for and relations with the public is to have the system operate smoothly and efficiently, because every single thing which is done within the organization has some effect on the customer or the public on the outside.

It now follows, logically, that this smooth running and efficiency rests with each and every one of the employees and so the co-operation of an enthusiastic and well trained staff must be secured. It is not a one-man job or even a departmental job, but concerns the commissioners and staff down to the office boy.

The *Electrical World* is authority for the following statement: "Happiness in one's work springs from many causes. There is the work itself,

Presented to the Ontario Municipal Electric Association and the Association of Municipal Electrical Utilities at Toronto, February 7, 1940.

the compensation, opportunity for advancement, job security, retirement pensions, attitude of management as reflected by the boss.

"The work of public utilities men is pleasant, clean and, except for the unusual emergencies when everybody gives of his utmost, is not slave driving in nature. This, plus the stability of employment, old age security, and certain other advantages, such as sickness relief etc., caused people to seek jobs with the utilities; notwithstanding the fact that with job security must necessarily go slowness of advancement, and fair but not the large compensation of competitive employment."

Surely if these are the means to happiness in one's work, then the average Hydro employee has a decidedly good chance of realizing that state. Add to these things the feeling that he has an opportunity to become a really good public servant, to accomplish things a little above the ordinary, to display a little more skill than is called for in the usual daily routine, then supply the training which will enable him to give the right answers, as well as the training, if necessary to do his regular work better.

In the selection and training of employees it is necessary first that they be skilled in their technical and mechanical characteristics and then to see that their comportment towards the public both "on duty" and "off duty" is good. They must be instructed how to receive criticism; they must have not only a knowledge of the rules and regulations, but the reasons for their adoption. They should be kept informed of the activities of the whole organization, a weekly bulletin being a good medium to obtain this result.

It is not the intention, here, to discuss the various methods of selecting and training employees, but only to emphasize the necessity of such selection and training. Remember, it is difficult to teach an old dog new tricks, therefore, employees must be well selected and trained early. Notwithstanding all the selection and training that can be done, the employee remains a human being just as much as any member of the public. Any red-blooded employee can only be expected to stand so much abuse, and explosions may be expected occasionally, but courtesy should be the rule. However, it is very easy to overwork such phrases as "I'm sorry", "Please" and "Thank you". The public will laugh at "that symbol of insincerity, the artificial honeyed voice". It is much better to be natural, but again it is emphasized that employees, who come most frequently in contact with the public, should be selected because they are naturally pleasant, reasonable and, above all, intelligent.

Employees should always be courteous but they must also be firm when necessary. The old slogan "The customer is always right" is an indication of weakness on the part of the management or a willingness to bribe the customer for the sake of peace and good-will at any price. In a publicly owned utility such as Hydro, no employee has any right to extend favours to one customer at the expense of the others. Undoubtedly the customer is often right and the job is

to find out what it is that the customer is right about, and just why he is right about it. Again when he is wrong it is equally important to determine why he is wrong. It is no use to say that the public is stupid, although someone has facetiously suggested that the prospective customer should undergo an intelligence test before being connected to the Hydro system. However, if something can be done courteously and patiently to instruct the public, good results will be attained. A curbside philosopher expressed himself thus: "It ain't ignorance, so much, that does the harm, as folks knowing so many things that ain't so".

If sometimes one is apt to conclude hastily that the public is not overly intelligent, there is no excuse for lack of intelligence and knowledge on the part of the Hydro employees. Nothing will create bad public opinion more quickly than incorrect or insufficient information and advice from employees. Customers should not be re-directed from one telephone to another or from one desk to another. Intelligent and helpful assistance should be forthcoming instantly. Again, when there is the least reason to suspect that the customer is right, he should be given sympathetic attention. There are just as many lessons to be learned from the complainant as from the enthusiast. It is necessary for every employee to keep an open mind and to avoid the attitude, that everyone who differs with him is either a crook or a moron.

With just the right attitude acquired by the employee in treating the public decently, the man in the street is apt to say of Hydro, "Well, maybe that outfit is paying high wages and salaries at my expense, but look what you get—it's a wonderful service and a crowd of great people".

The manager is, of course, responsible for the operation of the system and the conduct of the employees. By his personal contact with and example to the staff he can create an esprit de corps which, to the Hydro, will be an asset beyond price. But the manager and his staff are not alone responsible for the public's opinion of the organization. There are the commissioners who are elected by the people, and, it seems to be a fact, that the best of municipal elected representatives are the Hydro Commissioners, but notwithstanding this, it has happened frequently in many municipalities that good public relations have been injured by thoughtless statements and actions by commissioners. Could not the "washing of dirty linen" which is sometimes necessary, be done in private for the welfare of the system and, therefore, in the public interest? Would it not be wise for a commissioner, before discussing the affairs of the Hydro on the street corner or at a meeting, to ask himself what his attitude might be if he were a majority stockholder in the enterprise? Commissioners can assist greatly in creating better public relations.

The General Motors Corporation has a slogan "Find out what the public likes, and do more of it; find out what the public does not like, and do less of it". When the customer does not like the service, either there is something wrong with the service, or

else there is something wrong with his understanding of it, or maybe it's something wrong with both. Remember that the customer is becoming an expert in the application of Hydro service; he knows what he wants Hydro to do for him and he believes it is the Hydro man's job to do it in spite of all technical difficulties.

Hydro has done a good job and rendered good service, but because of that very fact even better service is expected. Twenty-five years ago long interruptions were commonplace; to-day, momentary breaks in service rouse the public to anger. Voltage regulation that was thought good at one time by Hydro engineers is often found unsatisfactory, without the aid of a voltmeter by customers to-day who have been made light conscious by the Better Lighting Campaigns.

The General Motors' slogan may be sufficient for a private enterprise with goods to sell for profit, but a public undertaking like Hydro should go further. Abraham Lincoln said, "He who moulds public opinion is greater than he who enacts the laws". Because the public cannot possibly understand all the details and workings of the Hydro system as thoroughly as do the executives and engineers, it is evident that the opportunities are not limited to meeting the demands made by the public, but rather require these heads of Hydro to be the actual creators of public opinion.

Principal Wallace of Queens University, speaking before the Professional Engineers of Ontario a week ago in this hotel, stated that if social and economic progress had lagged behind scientific and engineering development, then, the responsibility rested with the engineer to use his special training to correct such a condition. Is it not suggested, then, that here is an opportunity for Hydro men to see to it that all the social and economic benefits to the public are fully obtained from such an excellent engineering accomplishment?

A whole generation has passed since the newspapers ran, almost daily, eight column headlines about Adam Beck and his great public ownership enterprise. It is quite possible, that a majority of the younger generation in Ontario, to-day, could not unhesitatingly answer the question, "Who owns Hydro?" But in the early days of the enterprise everyone knew all about it, and an excellent job was done in moulding public opinion.

Here, it seems appropriate to lament that no one has yet written a good biography of Sir Adam Beck; the longer it is left undone, the more difficult it will be to collect the data when his contemporaries are gone.

Hydro has since done much that the public would applaud if it knew more about it and a number of recent publicity programs by the Ontario Commission have taken full cognizance of this fact. Local commissions would do well to follow up such programs although it is recognized that to promote and complete them successfully is not a simple task. The high pressure salesmanship of these days in big business by personal contact, in print, and on the air has made the unbelievers mighty in the land.

Good and close contact with the local newspapers is essential. Lots of facts about the activities of the sys-

tem, monthly financial reports and statistics create interest, especially if they are served up in a way which illuminates them with new and credible facts. The newspaper stories need not always be good or sugar-coated news. If information is freely given about faults and mishaps, a greater spirit of trust and acceptance will be found amongst the public. Truthfulness and sincerity are the greatest factors in a Hydro public relations program. The President of the United States in his Jackson Day dinner speech a few weeks ago said: "Motives in the long run are what count—motives and good manners".

A word on advertising may not be out of place. The advertisement which devotes itself to selling an appliance or a concrete service seems to produce more direct results than any other kind, but the advertisement known as "Institutional Advertising" is probably not without its effect, although this type should not be too idealistic. It should contain hard facts, and be straight from the shoulder with a punch. Here is an advertisement in the yearly financial survey of the London Free Press—

TO THE CITIZENS
OF LONDON!
This Advertisment is
Published at your expense.

We make this extraordinary statement in order to startle you into a realization of the fact that the Public Utilities are your business, and yours alone. Your responsibility is not relative but absolute. It doesn't concern anyone else, and so with complete clarity of vision in the matter, make it your personal affair to support your Public Utilities in every way. Don't allow your interest to wane with the thought that "Business is up, rates reduced and the financial balance satisfactory". Keep in mind the cost of operation but also remember the quality of the service to you and your fellow citizens.
Hydro, Waterworks, Parks, Playgrounds, London & Port Stanley Railway — Use Them.
The Public Utilities Commission.

Considerable reaction was obtained and on the whole the public took it in good part and in discussion appeared a little chastened by their lack of interest and responsibility. The Public should be told more about its responsibilities, than of its privileges in these days of tottering democracy.

Another way to stimulate interest and lead opinion is through the schools. It has been suggested to the Ontario Commission that a pamphlet be printed in co-operation with the Department of Education of the Province for use in the class known as "Business Practice" now on the curricula of all secondary schools. At present quite a lot of misinformation is being handed out by teachers lacking correct data.

The demand for special service by the public from the utility grows constantly and adds to the cost of operating the utility. Commissioners may have wondered why unit costs of operating local plants continue to increase when they might naturally be expected to come down with in-

creasing numbers of customers. An investigation will readily show that the public is demanding, and is getting many times the amount of service compared with that rendered in years gone by. Immediate connections and disconnections, night service men, messengers to take applications, longer office hours for payment of bills, home service men, together with many other services which might be mentioned, are the reasons for these rising costs. Whether or not it were advisable to pamper the public is not now a question; it is not possible to turn back, and everything should be done to keep these services on the most efficient plane.

It is believed that the utility should make available every service demand by the public and within the power of the staff to accomplish, but these services should be paid for by the customer receiving them, unless they are such as any customer is likely to require through no fault or special desire of his own. If some special service is sought, even if only remotely connected with Hydro activities, it should be willingly given if any member of the staff has the technical or mechanical ability to perform it, and if there is no conflict with any local commercial or professional interest.

While writing this paper, the author has been alternately beset by waves of cynicism and idealism, of pessimism and optimism, and an effort was made to maintain as flat a load chart as possible, but it would appear that there are more peaks than valleys, and so one more peak,—it is a quotation from a speech by Sir Adam Beck at a complimentary dinner tendered to him in 1913 by the grateful citizens of London, Ontario. He said:

"I am the servant of the people. My greatest joy is to make the lot of everyone within the range of my work and influence brighter, and better. If I have helped to make the goods of the merchant, and the home of the poor safer from fire, I am glad. If I have helped to lessen the cares of the housewife by making electricity her servant, I have my reward. If I have helped the farmer to make life more attractive to the boys and girls on the farm, then I have not labored nor have you co-operated with me in vain. If I have helped to save the life of any afflicted child or lengthened the days of any afflicted, I am happy. The day of the people is come. In the winning of these great victories I am but one, but you are many. Let us set our faces toward the attainment of even greater things."

And so in conclusion; it is suggested that those gathered here representing this great Hydro movement assume the roles of disciples, interpreters and leaders. If this advice is accepted, no one can tell what fascinating possibilities the future may hold in better living for the people of this Province.

An Outline of Unit Substations For Distribution Systems

By C. H. Hutton, B.A.Sc., M.E.I.C., Chief Engineer, Hamilton Hydro-Electric System

Some of the illustrations referred to have been omitted in the printed copy of this paper. These and additional illustrations were shown by the speaker during his talk—EDITOR.

THE City of Hamilton proper is about 6¼ miles long and varies in width from about 2 to 3¼ miles. In this area there are at present eight 25 cycle and one 66 cycle 13 kv. step-down transformer substations and three 66 cycle 44 kv. substations, 12 in all belonging to the Hamilton Hydro. Heavy industry is served in addition through eleven 13 kv. "customer" substations chiefly in the northern sections of the city. Of the eight 25 cycle 13 kv. stations three are of the conventional type and are operated by 3 shifts of operators, one man to a shift. Five are unattended "Unit Substations" operated on the synchronous visual supervisory control principle over four telephone leads from three of the attended substations, so that we have at any one time three operators on duty responsible for the operation of eight stations. A roving attendant looks after the housekeeping of the five unit substations. Each of the eight supervised substations receives potential from the 13 kv. sub-transmission system of the Hamilton Commission, most of which is underground lead-covered cable.

The 13 kv. sub-transmission system is in turn fed from three H.E.P.C. 110 kv. terminal stations, one at each end of the city and just outside the present corporation boundaries and the third very close to the commercial and residential load centre within the city proper.

Circles with a half mile radius drawn about these eight substation sites will touch or overlap in the case of six substations. Circles one mile in radius will overlap two or more other one mile circles and cover the entire city with the exception of a strip on the south escarpment area of relatively low load density about ⅓ mile wide and a little over 2 miles in length.

One 66 cycle 13 kv. substation now of little importance is, incidentally, completely automatic consisting of a railway mercury arc rectifier and a couple of distribution feeders equipped with re-closing circuit breakers.

It is axiomatic in the distribution of electrical energy that we may effect maximum efficiency by transmitting the maximum distances possible at the maximum voltages that are available to us and the minimum distances at the lower potentials that we must nec-

Presented to the Association of Municipal Electrical Utilities at Toronto, February 7, 1940.

essarily use to enable men to work with safety on energized circuits.

Hamilton may be taken as a typical Ontario municipality where we have say 13 or 26 kv. supply voltages from the Provincial Commission and 2300 or 4000 v. municipal primary distribution feeders and 115-230 or 550 v. secondary. Thus the more we can make use of the 13 kv. potentials to deliver blocks of energy to local load centres throughout the municipality and the shorter we can make the length of the 2300 or 4000 v. feeders, the more nearly will we approach conditions of maximum efficiency.

If we must reduce the length of our 2300 or 4000 v. distribution feeders to effect this end, it follows that we must provide a greater number of step-down transformer stations located closer together and the more we have the smaller they will become initially. As the load density increases in any of these local substation areas, it then becomes only necessary to increase the substation capacity and run additional feeders and not necessarily to increase the number of substation locations.

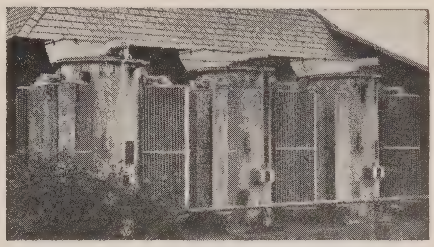
For each feeder voltage level, 2300 or 4000 volts, there appears then to be a spacing of substations which should not be exceeded and which should be selected and worked to in our layout program for future development.

It is not so very long ago that a new substation required an additional crew of operators, so that while it has always been more efficient to make maximum use of the H.E.P.C. supply voltages in preference to relatively long primary feeders and space the substations relatively close together, it certainly was not more economical to do so.

The development of station transformers, especially 3 phase, circuit breakers, on load potential regulation devices, metal-clad unit assemblies for both outdoor and indoor use, together with the means for the automatic or remote supervision of these elements of substations, has now changed the economics of substation spacing and made it quite possible for us to locate substations with some consideration to local load centres, feeder voltage levels and lengths of feeders.

The component elements of substation design have become more or less standardized with some manufacturers, as have types of assemblies of these elements, so that now we may have a factory made assembly of standardized elements wrapped up in one, two or more metal-clad packages and referred to as a unit substation. Such assemblies can now be obtained for indoor, outdoor or submersible installation or part outdoor and part indoor. They may also be obtained suitable for radial distribution systems, or network distribution systems, or for customers' substations. These assemblies take different forms depending upon the use to which they are to be put. It may be of interest to you gentlemen to consider here some of the types of equipment commonly known as factory assembled or unit substations and some of the applications that have been made, together with a word or two as to their principal detail.

Cut No. 1—Kenilworth Ave. station.



Cut No. 2—Rear of Kenilworth Ave. station showing transformers.

The Hamilton Hydro was one of the first in Ontario to take advantage of factory assembled or unit substation elements. Perhaps that is why your papers' committee has asked me to give this brief outline of this subject today.

Very recently, three residential type unit substations were completed and put in service in Hamilton that have provoked some favorable comment — one in the extreme south-easterly portion of the city known as the Kenilworth Ave. Station, one in the west district known as Stroud's Lane Station, and one on the south-west of the city known as Aberdeen Ave. Station. These three residential substations are almost identical in equipment, differing only in the architect's treatment of the building. The unit elements comprising the equipment in these stations are as follows:—

Unit No. 1—Consists of 3-1500 kv-a., o.i.s.c.r. transformers stepping down from 13.2 kv. to 2300 volts.

Unit No. 2—Comprising the 13 kv. oil circuit breaker assembly consisting of 2-13 kv. oil breakers together with their associated oil disconnecting switches, meters and control equipment, shop assembled in one metal-clad gum-filled package.

Unit No. 3—Comprising the 2300 v. oil circuit breaker unit assembly consisting of 8-2300 v. feeder breakers together with their associated oil disconnecting switches, meters and control equipment, shop assembled in one metal-clad gum-filled package.

Unit No. 4—Comprising the control unit assembly and consisting of the supervisory relays, station service equipment, battery charging devices, etc., mounted on sheet metal panels and screened from accidental contact by appropriate metal screens.

In addition to the above units there are two batteries, one 125 volts for breaker operating energy and one 45 volts for supervisory control energy, and the customary interconnecting power leads, all of which are p.i.l.c. cables. With the exception of the transformers, these unit assemblies are all indoors and housed in protective buildings conforming architecturally with the surrounding neighborhood. All equipment, both indoors

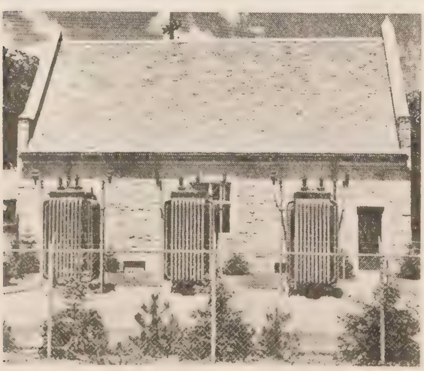
Cut No. 3—Stroud's Lane station.

and outdoors, is arranged so that there are no exposed energized parts. In fact, we think it quite impossible for anyone to make accidental contact with an energized part even should they choose to climb over the permanent equipment.

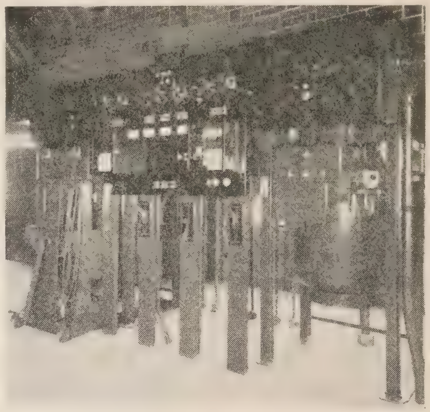
These three unit stations in Hamilton may be taken as a conservative application of the unit substation idea, consisting as they do of three indoor and one outdoor unit assemblies.

Cuts Nos. 1, 2, 3, 4, 5 and 6 illustrate these residential substations.

Cut No. 1 shows the front view of Kenilworth Ave. station and Cut No.



Cut No. 4—Rear of Stroud's Lane station showing transformers.



Cut No. 5—Thirteen kv. oil breaker unit assembly in Stroud's Lane station.

2 a rear view. The three 1500 kv-a., o.i.s.c.r. transformers are effectively screened from view by an ornamental wall on the street side.

Cut No. 3 shows a front view of Stroud's Lane substation and Cut No. 4 a rear view. The three 500 kv-a. transformers are installed temporar-

Cut No. 6—Twenty-four hundred volt oil breaker unit assembly in Stroud's Lane station, control unit assembly in the foreground.

ily during load growth. The screening here is being carried out by evergreen planting. The permanent transformers for Stroud's Lane will likely be three 2000 kv-a., o.i.s.c.r.

Cut No. 5 is a view of the 13 kv. oil breaker unit assembly in Stroud's Lane station. A transfer truck for the lowering and moving of oil breakers may be noted in position parked beneath the breaker tank on the left.

Cut No. 6 is a view of the 2400 v. oil breaker unit assembly at Stroud's Lane station together with the control unit assembly in the foreground. The 2400 v. oil breaker transfer truck is parked on the extreme right in this view.

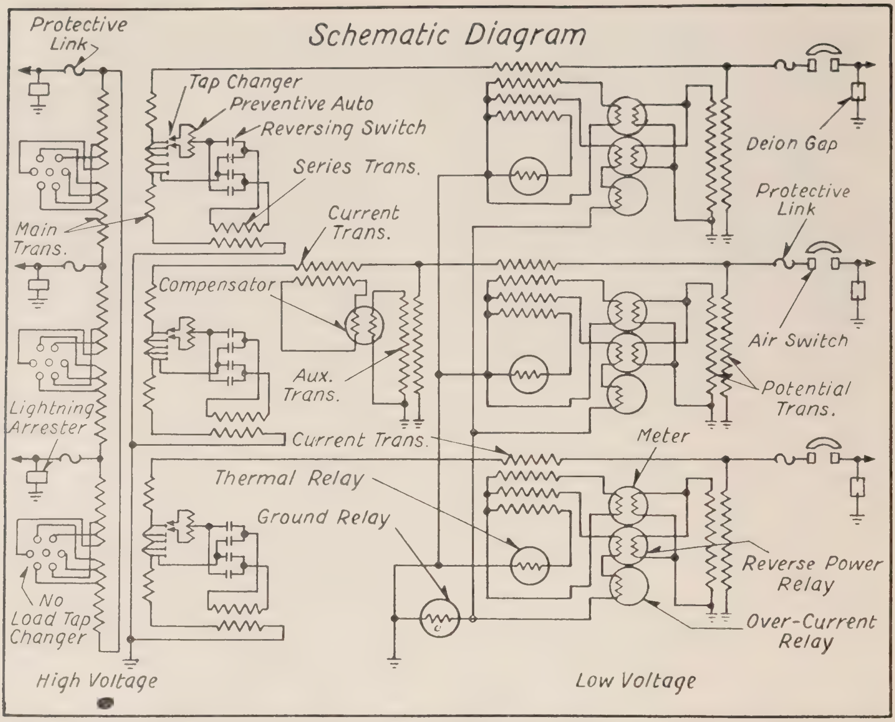
The ultimate development in the unit idea is where all the unit assemblies are combined in one factory made package, the whole made weather-proof by metal housing. Strange to say, such one package assemblies are referred to not as unit substations by the manufacturers, but as protected power transformers. These protected power transformers, however, combine in one piece of equipment the following functions normally associated with a complete conventional substation, but with the added factors of economy, safety and convenience:—

1. Voltage Transformation.
2. Automatic Regulation.
3. Automatic Switching.
4. Thermal Protection.
5. Metering.
6. Lightning Protection.

Let us inquire as to just what is embodied in a typical one package unit or protected power transformer—

1. We have, let us say, a 1000 kv-a., 3 phase, o.i.s.c., outdoor type transformer perhaps 13 to 4 kv.
2. Automatic on load tap changer equipment to regulate the output potential from say 5 per cent above normal to 5 per cent below normal in equal steps. Equipment has direct motor drive, position indicators and operation counters. Preventive auto transformers, necessary current, potential and power supply transformers located in the main transformer compartment under oil. Remote manual and automatic control equipment including time delay relay and line drop compensator, usually mounted on a separate hinged panel in the control compartment.
3. The low voltage or feeder switch—usually an air switch mounted in the switch compartment, d.c. operated, with an interrupting capacity of perhaps 75,000 kv-a., together with remote manual and automatic control for the switch mounted on a hinged panel in the control compartment. Operation counters and position indicator. Control relays to provide tripping on—
   (a) Excessive transformer winding temperature.
   (b) Over-current.
   (c) Ground Current.
   (d) Reverse Power.

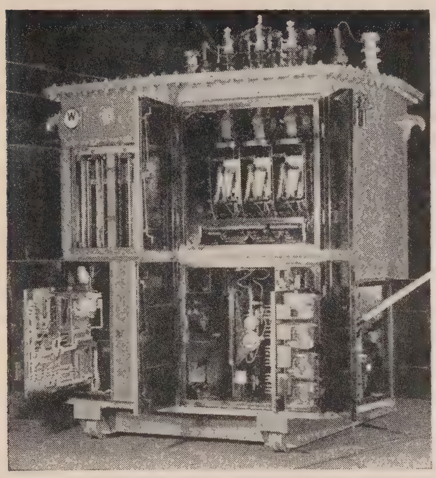
   Automatic re-closing for three reclosures followed by lock-out. Indicating lights to show Switch Open, Switch Closed, Tripping Circuit is energized.
4. Protective links mounted inside the transformer tank between both



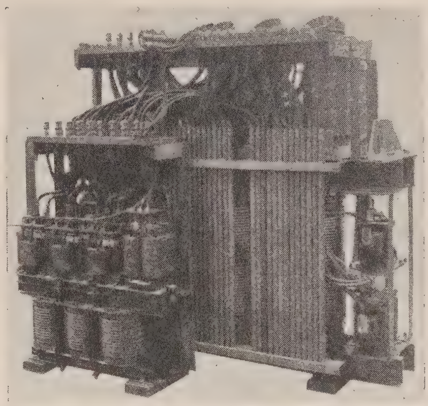
Cut No. 7

high voltage and low voltage incoming lines and the transformer, so arranged as to disconnect the lines in case this may be necessary. Potential and auxiliary transformers are also protected by individual links.

5. Metering—usually consisting of a three phase watt-hour demand meter mounted on a panel in the control compartment for registering the output of the transformer.
6. Thermal protection—three thermal relays calibrated with actual temperature of transformer windings and mounted in the main transformer compartment. Two sets of contacts are provided, the first to indicate by individual lights when the maximum desirable winding temperature for continuous operation in any phase has been reached, the second to trip the low voltage switch on excessive winding temperature.
7. Lightning protectors. These are mounted on the transformer and connected to the high and low voltage bushings and grounded to the tank. Inert gas cushion is automatically maintained at suitable pressure in the upper part of the main transformer compartment. The assembly is usually equipped with broad flanged wheels to facilitate installation and relocation.



Cut No. 9—Low voltage side of a self contained unit with doors opened showing tap changer, meter panel and relay panel.



Cut No. 11—Low voltage side of transformer unit, case and metering etc. removed.

Such a unit is shown in schematic diagram, Cut No. 7, and photographic cuts Nos. 9 and 11 (cuts No. 8, outside view of unit and No. 10, high voltage side, case removed are omitted).

Cut No. 12 (illustration omitted) shows a conventional outdoor substation of comparable capacity by way of contrast with Cut No. 8.

(To be continued)

The Municipal Hydro-Electric Pension and Insurance Plan

IN the previous reports which have been made by the Committee which administers this plan, we have dealt with the history and the organization, from the original proposal which was considered at the Convention at Niagara Falls on June 24th and 25th, 1925—and this plan, after compiling a great deal of data, and having a number of conferences with various Insurance Companies, was brought into being in 1929. So, we now have a number of Municipal Authorities which have been carrying Insurance and Pension for employees for at least ten years.

Two years ago, a report was presented at the Annual Convention on February 8th, 1938, which gave details as to the system under which

Report presented to the Ontario Municipal Electric Association and the Association of Municipal Electrical Utilities, Toronto, February 6th, 1940.

the various branches of the plan were being carried out, and showing the different options in respect to insurance, and the divisions of the Pension Scheme dealing with Service Annuity A, Service Annuity B, and Income Annuity Pensions—and explaining in detail how each of these service plans was being operated.

Under the agreement with the insuring companies, which was for a ten year period, a conference was to be held at the end of this time to arrange rates for a further period—and this conference was held between the Committee and the Insurance Companies, and the Hydro Electric Power Commission of Ontario — and a report which had been carefully prepared by Professor Mackenzie, M.A., Actuary to the Commission, was considered by the various bodies; and after considerable negotiation, a new contract was entered into for a further period of five years, and which applies to each of the Municipal Authorities as they reach the end of their ten year period.

There has been no change in rates for those employees of the various Commissions who had entered into the Plan during the first ten year period, but there has been a slight increase in rates for new employees entering the service of the Municipal Authorities after May 1st, 1939, and to all Municipal Authorities and their employees entering the Plan after that date.

The Companies felt that the interest on the Joint Deposit Account, which had been 4¼ per cent was more than they could afford to pay, and they suggested reducing this interest to a rate of 3½ per cent, but eventually the new contract was arranged so that the Joint Deposit Account would bear interest at the rate of 3¾ per cent—which the Committee considered a very fair and reasonable rate in view of the general reduction in interest rates during the past ten years.

You will see by the report which follows that our Organization is still growing, and comparison with the previous report shows that the number of Municipal Authorities has shown a steady increase over the years, as well as the number of employees, and the amount of Insurance Benefit in force.

We have succeeded during the past year in having the Commissioner of Income Tax grant to all employees the right to deduct from their income taxes the amount paid by them in pension premiums.

We have had a number of conferences with respect to carrying insurance on employees of local Commissions enlisting for active service Overseas and negotiations have been carried on with the insuring companies, and a report prepared by Professor Mackenzie on the various suggestions made — one of which has been approved by the Committee and Hydro Electric Power Commission of Ontario, to provide for special insurance on all enlisted employees from the time they embark for overseas service, as well as on those members enlisting in the Aviation Corps to train as Fliers.

It was felt that the fairest way to deal with this matter was to have the cost of this insurance divided between all Municipal members of the Pension

and Insurance Plan in proportion to the payroll of each Municipality. There would be no extra charge for clerical work or administration of this special plan, and those employees who have enlisted, with the exception of those training for Fliers, would not be affected until such time as they embark for overseas. We hope to be able to give you the details of this separately, as they were not ready at the time of making this report.

SUMMARY OF OPERATIONS

		Jan. 1, 1933	Jan. 1, 1940
1.	Number of Municipalities included	45	60
2.	Number of Employees included	2,094	2,540
3.	Amount of Life Insurance Benefit in force	$4,370,550.00	$5,424,115.00
4.	Amount of Monthly Service Annuity Pension being purchased	94,412.00	110,230.00
5.	Amount of Monthly Income Annuity Pension being purchased	54,558.00	67,751.00
6.	Number of Employees at present drawing Pension	11	109
7.	Amount of Monthly Pension being paid	177.00	3,097.00
8.	Number of Employees who have reached Normal Retirement Age but have been retained in employment	18	32
9.	Amount of Monthly Pension being paid into Joint Deposit Account, with reference to those employees who have reached Normal Retirement Dates and who have been retained in employment	209.00	853.00
10.	Amount of Municipal Authority's 5% monthly payment	14,320.00	16,200.00
11.	Amount of Employees' monthly Income Annuity Payment	7,429.00	8,958.00
12.	Amount of Employees monthly Extra Contribution	215.00	686.00
13.	Number of Death Claims	39	152
14.	Amount of Death Claims	75,570.00	307,050.00
15.	Amount of Employees' Income Annuity Contributions refunded	12,225.00	95,871.00
16.	Amount of Employees' Extra Contributions refunded	540.00	5,436.00

MUNICIPAL HYDRO ELECTRIC PENSION & INSURANCE COMMITTEE

Jos. Gibbons, Chairman.

T. J. Hannigan, Secretary.

Hydro Homemakers' Forum

EAGER anticipation and keen enthusiasm were the keynotes of the audiences that filled to capacity the auditorium of the Public Utilities' building in Kitchener during the three-day session of the Hydro Homemakers' Forum.

The demonstrations were conducted by Ruth Crawford and Edithemma Muir. In the picture above, Miss Crawford is shown at the left, Miss Muir at the right, a completely equipped model kitchen forming an attractive background.

The latest methods in cooking were shown—in many cases almost the opposite of those Grandmother used—made possible by the high degree of perfection of the modern electric range. The ladies learned how foods cooked electrically retain their attractive appearance and appetizing flavor and lose none of their health-giving natural constituents.

Besides cooking, other interesting phases of Electrical Homemaking were discussed such as modern labor-saving home laundering, the proper use and maintenance of smaller appliances, and also the safe-guarding of precious eye-sight by means of adequate home-lighting.

The Hydro Homemakers' Club was explained as a means of helping members to obtain greater benefits from the proper use of their appliances and many new members were enrolled. Each member will receive regularly, copies of the Club Bulletin.

To date many municipalities have taken advantage of the opportunity offered to conduct similar Forums for the benefit of their consumers, a schedule having been drawn up for visits to twenty-nine centres during the next three months.

On completion of this schedule, arrangements can be made for other municipalities to co-operate in conducting Forums in their own centres.

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Extension to Hydro Office Building

RAPID expansion has compelled The Hydro-Electric Power Commission of Ontario to extend its head office building in Toronto. The extension has been needed for some years but the expenditure was deferred as long as the Commission's activities could be carried on in present quarters. Increases in power demands throughout 1939 have necessitated a very great increase in staff activity. The building extension is needed quite independently of the war. However the magnitude of war work increases not only the space requirements but also the importance of supplying it.

Although every consideration has been given to the possibility of deferring construction until after the war, that course is neither in the Commission's nor in the national interest.

The new building, six stories of which were constructed in 1935, will be completed to sixteen stories as originally planned, but the construction will be simplified and reduced in cost by the ommission of all non essential features.

For some time the Commission's work has been very seriously hampered by the inadequacy of its head office facilities. The staff is scattered throughout a number of buildings in the neighbourhood. The effective output of the staff is being curtailed in a manner and to an extent which cannot be overcome by simply adding additional staff in remote quarters, even though trained men were available in sufficient numbers, which is not the case. Bringing the staff together in a single building will insure greater promptness and effectiveness in delivering power to Ontario factories and hence give important aid to Canada's war effort.

Since 1935 the Commission has installed about $35,000,000 in plant, had an increase in total load of 500,000

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March, 1940

horsepower, and built nearly 8,000 miles of rural lines, necessitating a permanent 40 per cent increase in head office staff.

When complete, at a cost of $1,-100,000, the building will be immediately occupied to 80 per cent capacity, and should the St. Lawrence, or some other major power development be approved, the entire space will soon be fully utilized.

Before a decision was reached, careful inquiries were made to ascertain whether sufficient labour and building materials will be available without interfering with war efforts

Extension to Hydro Administration Building completed in 1935.

and the Commission is assured that it can proceed immediately without handicapping other essential operations. Over 95 per cent of the materials and 100 per cent of the building labour will be Canadian. Thus the effect upon exchange will be insignificant and as the building is of reinforced concrete very little steel will be required.

On Kite Flying

HOW many of us grown ups remember when it was a delight to pause at the sight of a kite in its flight, and better still to be thrilled with the tug on the kite string. In those days it was a sport that could be indulged in with complete safety. Not so today.

Kite flying still ranks as a major sport with boys.

The ever extending maze of electric power wires has injected a hazard into the sport which can be overcome by observing the following simple rules:

1. Do your kite flying in the wide open spaces away from electric wires and automotive traffic.
2. Build your kite without using metal parts.
3. Use a dry string for flying. Wire, damp string and string reinforced with metal, such as tinsel, are conductors of electricity and their contact with electric wires is dangerous.
4. Call your hydro service, should your kite become tangled in electric wires or become caught on poles. They will gladly remove it for you.

Parents, teachers and others who have a natural concern for the safety of children can assist in the campaign for safe kite flying by teaching these safe practices.

* * * *

In order that the dangers to be avoided when flying kites may be given as much publicity as possible, it is suggested that all local newspapers publish articles similar to the above, including therein the four mentioned rules for safe kite flying.—Editor.

Lighting For Learning

By George G. Cousins, Supervising Lighting Engineer,
The Hydro-Electric Power Commission of Ontario

THE value of education needs no emphasis. Legislation has been passed that makes attendance at school compulsory during the years in which any child should obtain at least the rudiments of an education. More and more study is being given to methods of instruction, the educational demands of employers upon applicants for employment are making it increasingly difficult for those having only lower school education to obtain work in any but the lower grades, and the qualifications for entrance to Universities are being raised. These facts clearly indicate that greater stress is being placed upon educational accomplishment; the latter two indicate the stern necessity of higher standards than those of a few years ago. These increasing demands point to the necessity for improved facilities for advancement and the detection and elimination of all the factors that retard the progress of pupils.

The newer methods of instruction undoubtedly have merit, but in one fundamental requirement advancement has not kept pace with the demand; and until the importance of this phase of the problem, namely, seeing conditions, is fully appreciated and steps taken to rectify their faults, there will continue to be the annual crop of disappointments, frustrated effort, loss of time (through repeating grades), wasted expenditure of money for reinstructing repeaters, and the ills associated with overworked and strained eyes.

It has been estimated and generally accepted that over 85 per cent of knowledge is gained through the sense of sight. It seems logical therefore, that the factors that influence seeing conditions should receive first consideration, and that immediate steps would be taken to rectify obvious defects in these conditions. On the contrary, we see many new schools in the design of which are incorporated the latest ideas in heating and ventilation, sanitation, floor construction, swimming pools, and other features, all of which contribute to the welfare of the pupils; but the seeing conditions, the most important of all, are far behind the scientifically established requirements of the present day. Furthermore, the consideration of lighting old schools seems to be too often based more upon how little money for which lighting of any sort can be installed, than a system that will fulfil the requirements of reasonable ease and certainty of seeing, and which would benefit all parties concerned—pupils, teachers, and trustees. The ability of the pupils to see clearly and without avoidable eye strain is of utmost importance and should be the first consideration. Artificial lighting is of value only to the extent that it makes

Paper presented to the Inspectors Section of the Ontario Educational Association at Toronto, March 29, 1940.

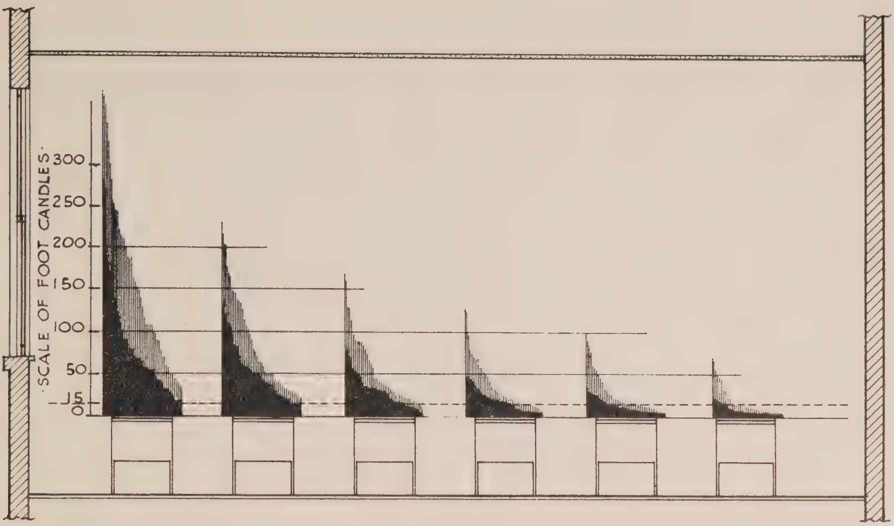


Fig. 1—Cross-section of class room showing range of intensities of daylight from the window side to the opposite side of the room.

seeing easier and is definitely beneficial to the pupils. It is the purpose of this address to present some facts to arouse interest in the other aspect of lighting, that of consideration of the needs of the pupils, and to point out that lighting can be a decided asset that will yield tangible benefits.

Daylight Conditions

Daylight is plentiful and free at nature's dispensary, but man's attemps to bring it indoors are fraught with practically insurmountable difficulties except at excessive cost. Consequently, in schools of reasonably modern construction, about half of the desks are provided with reasonable intensities of daylight, but the other half are not so fortunate. In old schools with small windows the conditions are far worse. Fig. 1 is a graph prepared from a great many measurements, made over a period of years, of daylight intensities on desks on both clear days, (represented by lightly shaded areas) and cloudy days, (represented by solid black areas). On each desk the height of any part of the graph represents the value in foot-candles of a corresponding height on the scale of foot-candles at the left. The variations in foot-candles shown on any desk represent the total range of values measured on corresponding desks in many classrooms in many schools. The graph is a summary of measurements made in schools in various parts of the province. A dotted line parallel to the desk tops at 15 foot-candles on the scale shows the value required by the Department of Education for artificial lighting. All the portions of the graph below this line represent daylight intensities below 15 foot-candles. Attention should be paid to the proportion of the daylight values below the minimum required for ar-

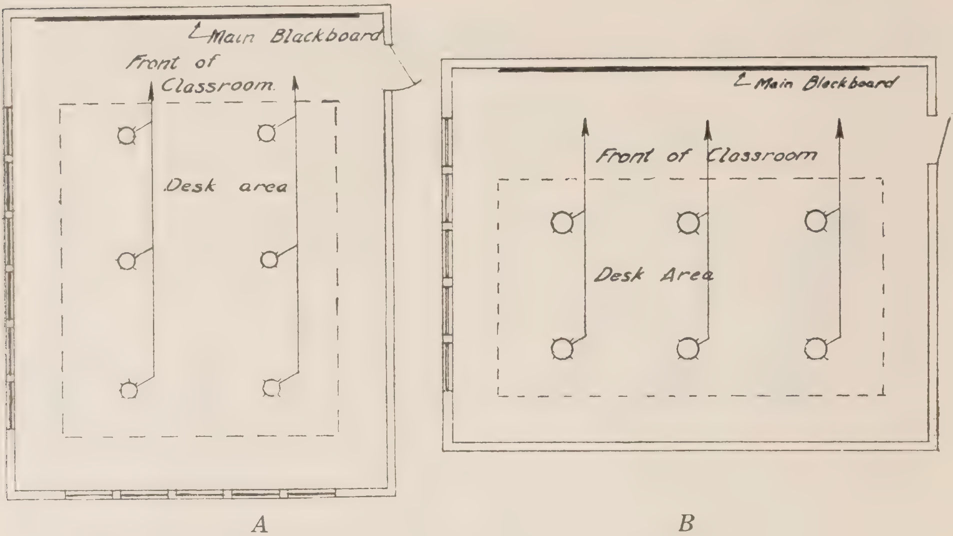


Fig. 2—Arrangement of lighting circuits in classrooms.
A—For standard shape.
B—For wide rooms.

tificial lighting. This applies particularly to the three rows of desks farthest from the windows, even on clear days.

On cloudy days nearly half of the desks on the third row from the windows and some on the second row are below 15 foot-candles. Records of daylight conditions in Ontario show that over 50 per cent of the days in the school season are cloudy. It is therefore obvious that the intensity of daylight is, on the whole, inadequate on about one-third of the desks. Many schools are very much worse than the average values cited. The most serious condition exists in the half of the room farthest from the windows, and it is fortunate that this can be remedied by the logical arrangement of the two rows of lighting fixtures in the average classroom, see Fig. 2, A. B, Fig. 2, shows the most suitable arrangement of circuits for rooms that are wide in comparison to the front-to-rear dimension. The foregoing facts indicate the necessity of adequate artificial lighting for daytime use.

Effect of Desk Location on the Visual Tasks

There are two separate and distinct visual tasks in ordinary classrooms, namely, seeing for writing as in ordinary desk work, and seeing what is written on the blackboard. Any inequality in the facilities for progress as related to desk work can be easily removed by a suitable lighting system; but the blackboard presents an entirely different set of conditions because the letters and figures written on it must be seen from different distances, from different angles, and under different conditions. From some seats the blackboard appears

relatively dark, forming a good contrast with the white chalk marks, and from others the blackboard is as bright (due to reflected glare) as the chalk marks, and the latter cannot be seen at all. It is obvious, therefore, that some pupils are highly favored and others severely handicapped, yet all are entitled to equal opportunities for advancement.

A great deal of classroom instruction depends upon the use of the front blackboard, and the greatest inequalities with regard to the pupils' facilities for correct interpretation of instructions are related to the blackboards. The blackboard, the most important detail of classroom instructional equipment, seems to have received the least attention. With the exception of badly defective eyes, practically all difficulties of seeing are directly related to lighting, either daylight or artificial, and the adoption of improved lighting will in all instances reduce the difficulties. This is a fundamental fact that should not be overlooked as the application of it will appear in what follows.

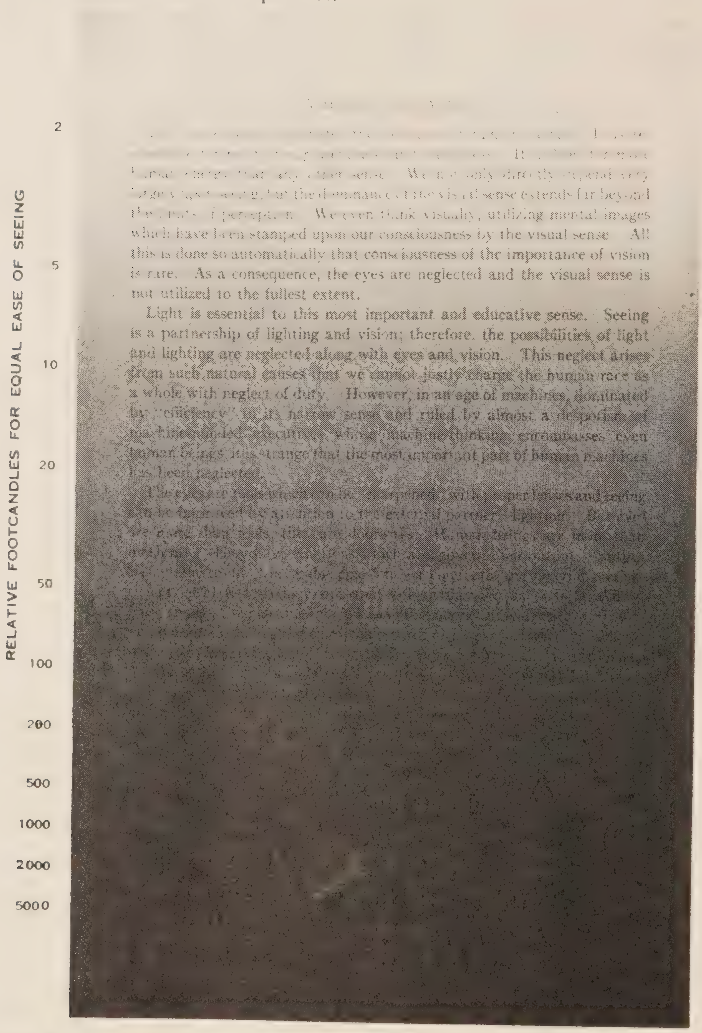
Our measurements of daylight illumination show that on clear days its average on desks farthest from the windows is about one-thirteenth the intensity on desks nearest to the windows, and on cloudy days the ratio is about one-sixteenth. A white page with black letters under high intensity lighting presents the maximum contrast, and consequently the greatest ease of reading. If the same page is observed under low intensity lighting the black ink is no blacker but the brightness of the page is reduced and there is therefore a lower contrast resulting in greater difficulty in reading. This is illustrated on the visibility indicator, Fig. 3. If the printing at the top of the indicator, at 1, represents the contrast on the page on desks near the windows then the contrast on the page on desks farthest from the windows will appear as that between figures 10 and 20 on the indicator. This is based upon the measured intensities of daylight. In other words, the difference in the ease of reading between the light and the dark sides of a classroom is represented by the difference revealed by the printing at 1 and that between 10 and 20 on this indicator. Naturally, reading or eye work in the dark side of a room produces more eye strain and fatigue than in the light side. These ratios apply to the average of the measurements that were made, not necessarily to each individual room, but they represent a general condition.

It is obvious that due to simple optical laws any object will appear smaller as the viewing distance is increased.

The Department of Education stipulates that the distance between the front wall of a room and the front row of desks shall not be less than 8 feet; but in many rooms, more particularly in rural schools, the front desks are as much as 12 feet from the front blackboard. This means that the pupils in the rear row are 4 feet farther from the blackboard than necessary, and their difficulty of seeing the work thereon is

Visibility and Ease of Seeing are closely related

Visibility increases as the intensity of illumination increases. So does ease of seeing. Read the printed matter below under different intensities of illumination and note the point at which reading becomes difficult or impossible.



We even think visually, utilizing mental images which have been stamped upon our consciousness by the visual sense. All this is done so automatically that consciousness of the importance of vision is rare. As a consequence, the eyes are neglected and the visual sense is not utilized to the fullest extent.

Light is essential to this most important and educative sense. Seeing is a partnership of lighting and vision; therefore, the possibilities of light and lighting are neglected along with eyes and vision. This neglect arises from such natural causes that we cannot justly charge the human race as a whole with neglect of duty. However, in an age of machines, dominated by "efficiency" in its narrow sense and ruled by almost a despotism of machine-minded executives whose machine-thinking encompasses even human beings, it is strange that the most important part of human machines has been neglected.

Fig. 3—Visibility Indicator (by Luckiesh and Moss). Showing relative lighting intensities required for equal ease of reading printing of varying contrast with the background.

correspondingly greater. This may not be a serious matter on clear days, but 50 per cent or more of the school days are cloudy. Furthermore, child-

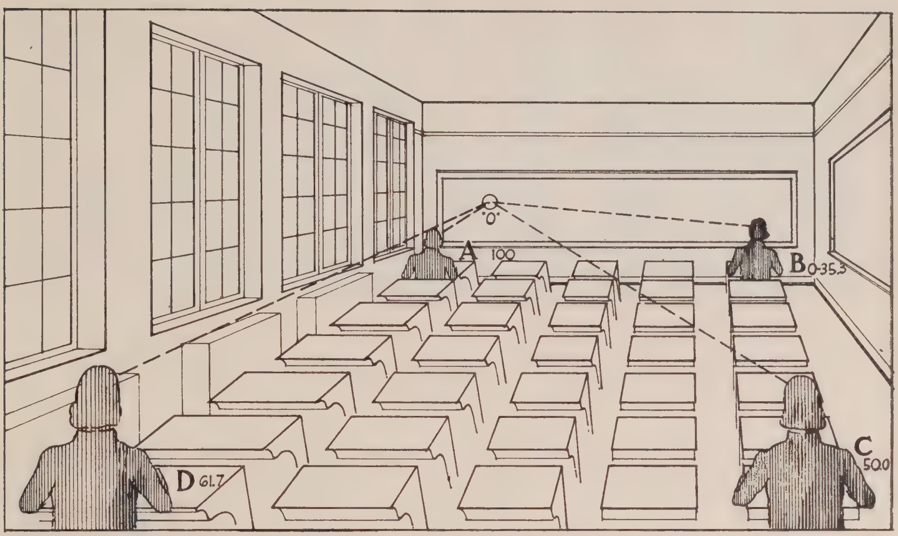


Fig. 4—Showing relative ease of reading writing on the blackboard from different positions in the classroom.

ren with subnormal vision may occupy the rear seats and the extra difficulty then becomes a serious matter. By moving the seats and desks forward it eases the tasks of the pupils occupying the rear seats. The argument is sometimes put forth that the space at the front is needed for a platform for concerts, but there are only a few of these in a year while the pupils are affected for 10 months of the year. The forward desks may be fastened in groups on boards so that they can be moved out of the way when necessary. At any rate, the children's welfare is of first importance and should receive first consideration.

Fig. 4 shows a typical classroom. From each corner desk an arrow points to a point "O" on the blackboard in front of the favored desk A, where the seeing conditions are the best of any desk in the room (except where there are windows at the right). The figures at the corner desks represent values of relative visibility of writing on the blackboard as viewed from the respective desks. The visibility at A is given as 100 and as percentages of A at the other corners. From desk B the visibility at "O" is often zero because of reflected glare. The lower values of relative visibility represent more difficult seeing conditions. For instance, from desk C the writing on the blackboard at "O" is twice as difficult to read as it is from desk A. This means that the eyes at C have to work about twice as hard as those at A which naturally results in more fatigue of the eyes, nervous system and body generally. It is not possible to completely eliminate these inequalities but the combination of good lighting, no glare and blackboard in good condition, will render seeing so easy that no

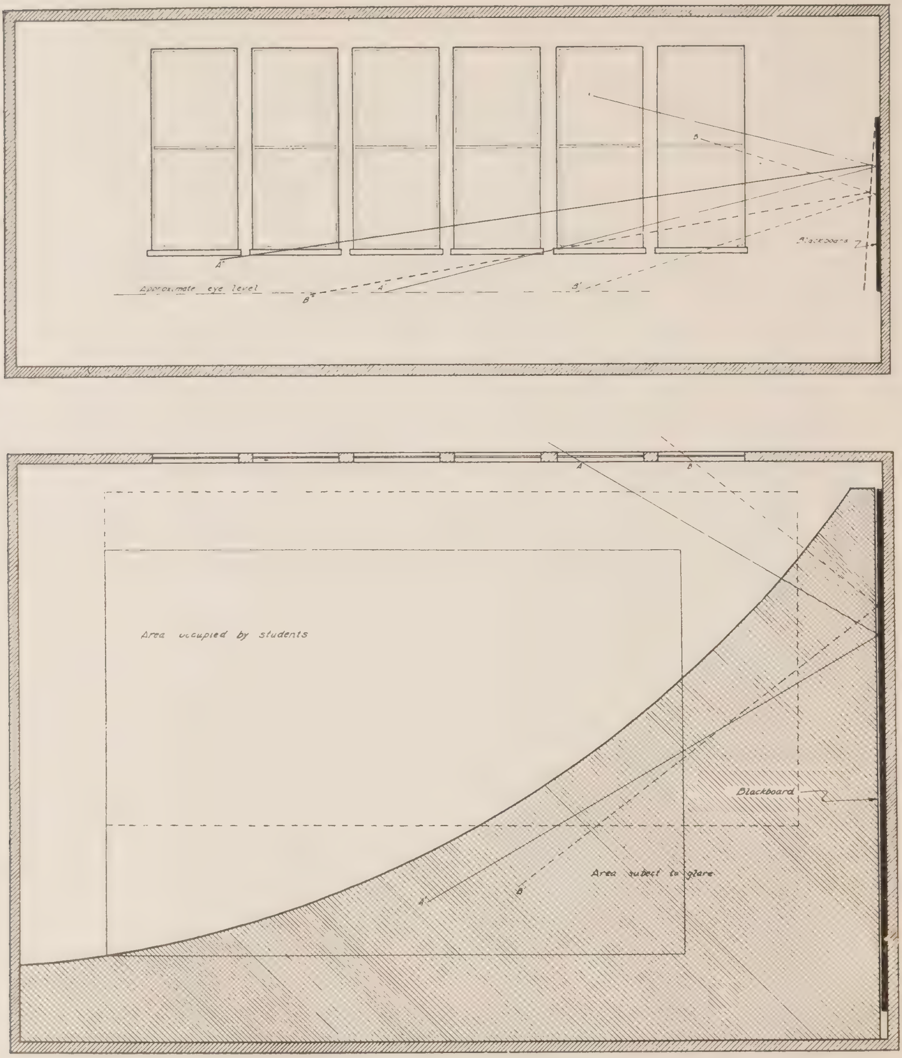
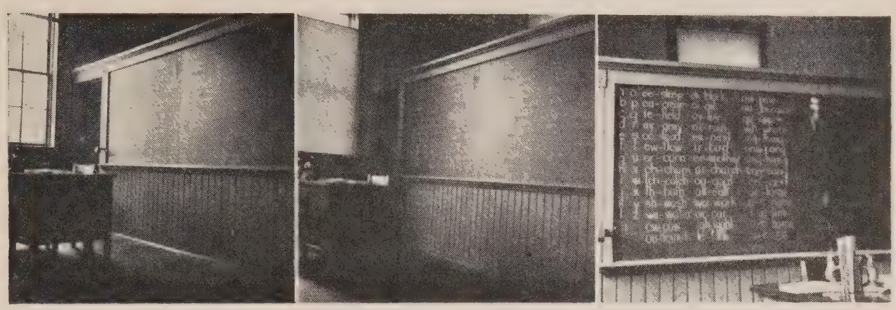


Fig. 5—Shaded area represents the zone within which reflected glare from the blackboard is seen. The upper section is a side illustration that shows how a sloping blackboard accentuates glare by causing the rays of reflected light to be reflected back into the room at higher angles than the vertical blackboard, which results in more of the occupants being bothered by glare than occurs with the vertical blackboard.

serious strain or fatigue will result. This condition clearly indicates the necessity of avoiding placing desks farther from the blackboard than necessary. Unnecessary distance results in a definite handicap. These



A *B* *C*

Fig. 6—Blackboard glare.

A—Glare caused by window at the left.

B—Window at the left (shown in the picture) screened by a window shade. The glare caused by the light from the window is eliminated but glare from the next window to it (not shown) is still visible.

C—Same section of the blackboard free from glare as viewed from desk "A" of Fig. 4.

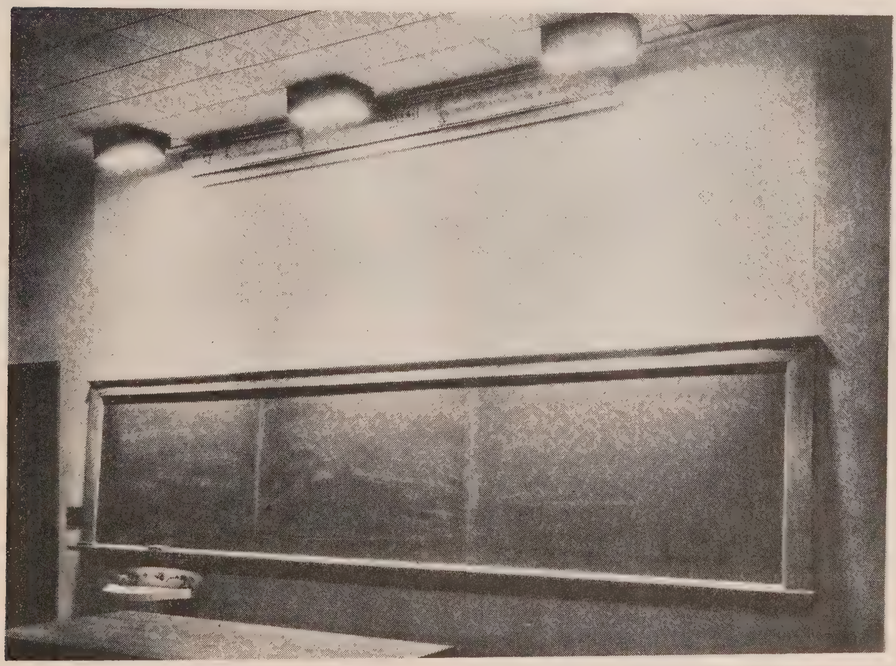


Fig. 7—Prismatic blackboard lighting unit. Each unit requires two 150-watt lamps.

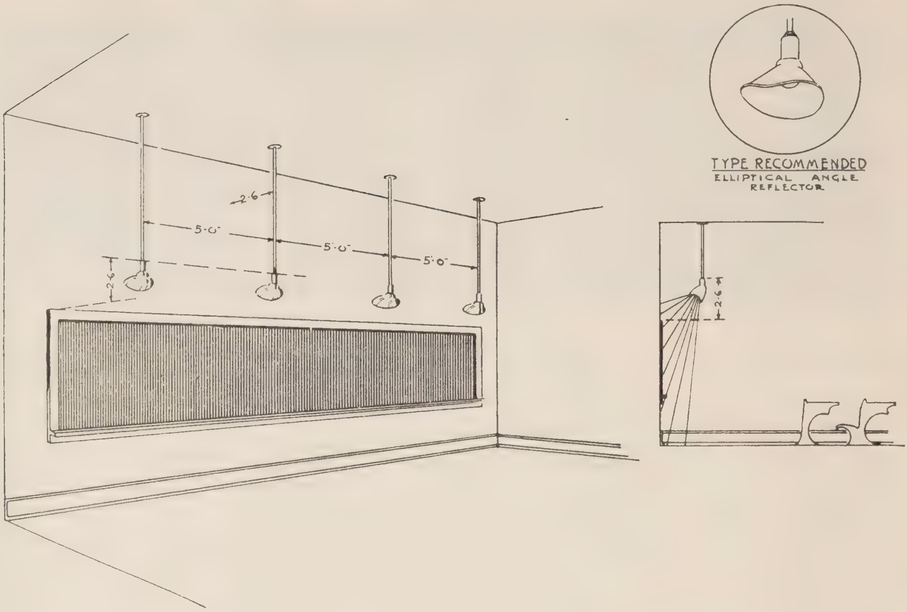


Fig. 8—Elliptical angle reflectors.

values of relative visibility are averages of measurements taken in several rooms.

One of the most troublesome obstacles to efficient use of the blackboard and the progress of the pupils is the glare near the left end. This is caused by reflections of the sky usually, and its effect is to completely obscure the writing from seats on the opposite side of the room. This is illustrated by Fig. 5 which shows a typical glare zone for a room with windows on the left side of the room only. If there are windows on the right and the rear, practically the whole room is a glare zone. The only practical method of eliminating the glare is to prevent the light that causes it from entering. This means the use of some kind of window shade. The offending light enters through one or more windows near the ends of the blackboard and is reflected by it to the opposite side of the room. When the windows are shaded the illumination of the blackboard is seriously reduced, see Fig. 6, and artificial lighting is necessary to restore visibility. Fig. 7 shows blackboard lighting produced by prismatic lens plate units designed specially for this purpose. Fig. 8 shows the use of less expensive equipment. The latter does not possess the refinement of the former, but where funds are strictly limited its use is fully justified and the results reasonably satisfactory.

Many teachers have contrived means of overcoming this serious handicap, but they all involve inefficiency in one way or another. Blackboard glare can definitely be eliminated by the combination of intelligently

used window shades and a properly planned system of artificial lighting.

Handicapped Children

The foregoing facts clearly show that the handicaps that retard children are not by any means all inherent in the children themselves. The pupils occupying desks nearest the windows are highly favored while those in the dark side of the room are doubly handicapped, first by the low intensity of daylight and second by blackboard glare. The only available method of minimizing these inequalities is based upon the use of adequate artificial lighting.

Special Classes

Sewing in domestic science and typewriting in business classes require good lighting for reasons of their own. Sewing is done with fine threads usually of the same color as the cloth which, with the speed of the machine, combine to produce an exceedingly difficult visual task. Even hand sewing imposes a severe strain on the eyes.

Stenography and typewriting are monotonous and nerve-wracking work because of the demand for speed, continuous application and accuracy. While it is true that the touch system does not require the use of eyes to guide the fingers, the eyes must follow the copy. If the lighting is poor the eyes use up an excessive amount of nerve energy which would be available for speed and accuracy under good lighting.

Trade training classes require the same types of lighting as the respective trades require in actual production. The lighting requirements of the various trades differ and each must receive attention and planning for its specific visual tasks. It is not sufficient to light the area in which work is done; the visual task itself must be lighted.

For draughting indirect lighting is necessary; there is no second choice and the intensity should be at least 25 foot-candles.

These special classes are for the purpose of teaching specific subjects that have for their aim the direct preparation of the students for gainful occupations. They should be taught correctly and as completely as possible within the limits of a school course; and as the sense of sight has such an important bearing on their success, it is important to provide lighting that will enable them to gain as much knowledge of their prospective work as possible. Accuracy (the first requirement) and speed (the second) are impossible without good lighting.

Sight-Saving Classes

Research in lighting has uncovered many interesting facts, among which is the fact that improved lighting creates greater benefits to subnormal eyes than to normal eyes. The students in sight-saving classes are on the border line between total disability (as far as sight is concerned) and partial disability. The seeing conditions, if poor, may put them in the former, but, if good, may keep them in the latter and give them a chance to fit themselves for independent activity throughout the major portion of their lives. Therefore, the best possible lighting should be provided, and full use should be

made of every possible means to assist the lighting, such as absence of glare, proper books with suitable paper, and blackboards when used, maintained in the best possible condition.

Persons with eyes that approach normal are constantly absorbing knowledge through visual impressions, and even they, at times, are handicapped by lack of good seeing conditions. How much worse, then, are those with subnormal vision who cannot see a great many of the things that impart knowledge to the others. Psychologists state that the average I.Q. of pupils of sight-saving classes is lower than that of normal pupils. Surely this is a situation where prevention of further disability by the best possible seeing conditions is worth any cost, but where cure is beyond all cost.

(To be continued)

An Outline of Unit Substations For Distribution Systems

By C. H. Hutton, B.A.Sc., M.E.I.C., Chief Engineer, Hamilton Hydro-Electric System

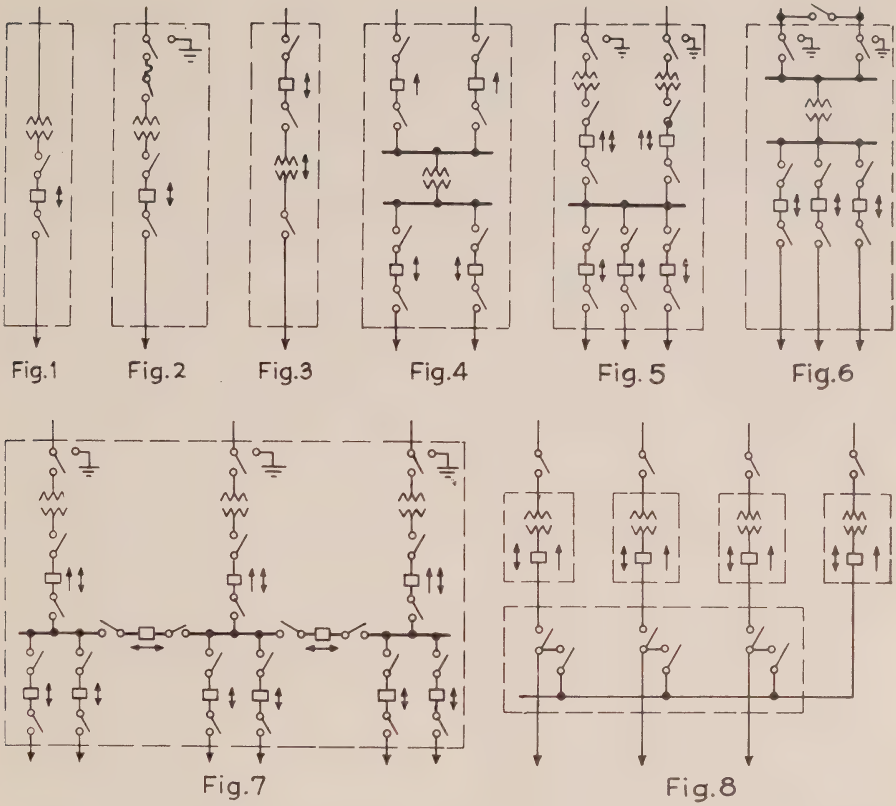
(Continued from February)

A survey of contemporary practice in the application of factory built or unit substations was published in the *General Electric Review* for May and June, 1939. The survey covered some 80 installations and showed that about the only feature common to these installations was the use of 3 phase transformers and automatic tap changing equipment. No two units were exactly similar, sizes varied from 500 kv-a. to 6000 kv-a. and potentials from 11 kv. to 69 kv. The installations varied in form and use throughout the range already mentioned today. Had the survey included the Province of Ontario, it would have indeed shown no features in common since the Ottawa Electric Co. uses induction type regulators and the Hamilton Hydro single phase transformers.

Let us run briefly over the results of the survey and look at some typical installations and their corresponding single line diagrams.

The accompanying series of figures numbered 1 to 8 in Cut No. 13 show in single line form the most common arrangements used in radial distribution systems. The portions shown inside the dotted enclosures have been installed as factory built assemblies.

Figs. 1, 2 and 3 show relatively simple single feeder radial substations. Such units are usually small in size, say 150 to 1000 kv-a. They constitute applications for rural service or small urban loads. Units of this type are usually equipped with only one feeder position although more can be used if found desirable.



Cut No. 13—Common arrangements used in radial distribution systems.

The units in Figs. 1 and 2 have low side circuit breakers with time over-current protection for feeder faults. Automatic multiple reclosing following over-current trip-outs is usually provided. In Fig. 2 the primary fuses and a three position grounding and disconnecting switch is indicated. When a part of the assembly, the two are mounted in a metal enclosed box on the side of the transformer. Usually these features are a part of the substation when the incoming circuit is an underground cable, whereas with cover bushings these devices are mounted on the nearest pole although they may be mounted on the pole in either case. The fuse may be desirable if the sub-transmission line feeds a large number of small units or if the station breakers of the sub-transmission line cannot be set low enough to trip out on transformer faults, but it is only occasionally that primary fuses have been considered necessary on units of this type.

In Fig. 3 the functions of the low side circuit breaker and the high side fuse are combined in the single high side circuit breaker. Where both primary fuse and low side circuit breaker are necessary, this alternative may

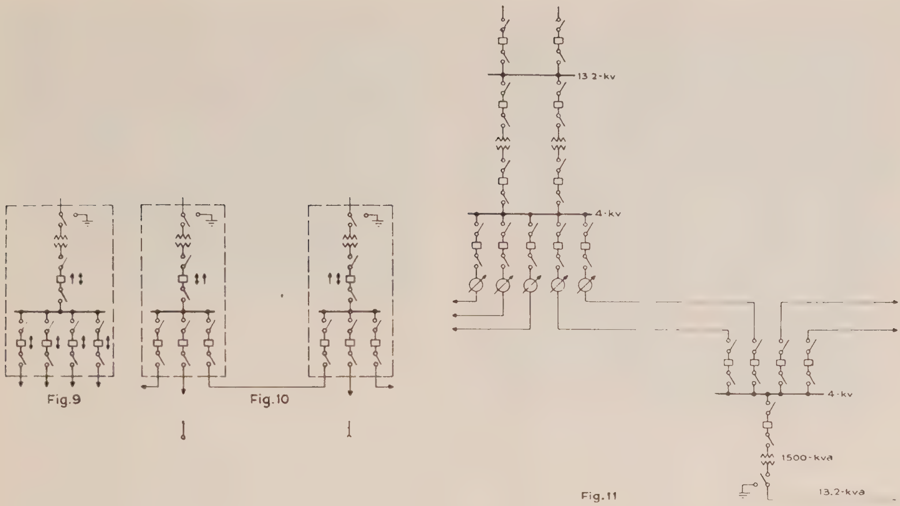
prove to be desirable. However, this arrangement is rather rare and it must be borne in mind that the high side circuit breaker necessarily entails a higher interrupting capacity and higher insulation level and thus is more costly than the low side circuit breaker.

Fig. 4 shows a fairly common arrangement used to tap a primary tie line. This is a typical arrangement for an industrial substation served by a 13 kv. loop circuit. These high side circuit breakers are equipped with directional relays and usually operate both normally closed. A substation such as this may or may not be equipped with low side feeder positions since the high side breakers may be equipped with over-current relays for protection of low side faults in a manner similar to that used with the substation Fig. 3. However, a substation of this type is usually of reasonable size and would naturally be equipped with one or more low side feeder positions.

A similar arrangement is shown in Fig. 6 except that instead of high side circuit breakers, disconnecting switches are indicated. This substation, of course, requires low side feeder circuit breakers for feeder fault protection.

Fig. 5 shows a unit equipped with two transformers and fed by two primary lines. This arrangement is sometimes called a spot-network, although strictly speaking it is a radial substation. Unlike any of the other arrangements shown in Figs. 1 to 6, in this case a transformer failure does not result in the loss of load. In the preceding types a transformer failure results in at least a temporary outage until the necessary cut-overs can be made. Each transformer in Fig. 5 is equipped with a transformer circuit breaker on the low side and any number of feeder positions may be provided. The transformer circuit breakers have directional relays for transformer faults and high side line faults. In addition, the transformer breakers are usually equipped with long time over-current relays for bus fault protection although differential protection has been used in some installations. These relays are arranged to lock out the transformer breaker and to trip and lock out the feeder breakers in the event of fault on the bus. The transformer breakers are usually relayed to reclose automatically when the magnitude and phase rotation of the voltage on the transformer side of the breaker are of proper value, unless locked out because of bus fault. The feeder breakers are equipped with over-current protection and usually automatic adjustable-time reclosing.

The basic idea illustrated in Fig. 5 can be expanded indefinitely as the load grows. For each new increment of load a new transformer and switch assembly would be added. Usually, however, if this scheme is carried to more than two transformers, the arrangement as shown in Fig. 7 would be used, incorporating bus tie circuit breakers, each bus section serving one or more feeders. This arrangement is preferable since it keeps the possible outage at a minimum in the event of a bus fault. The arrangement shown in Fig. 7, of course, can be expanded in small increments to take care of load growth as it appears.

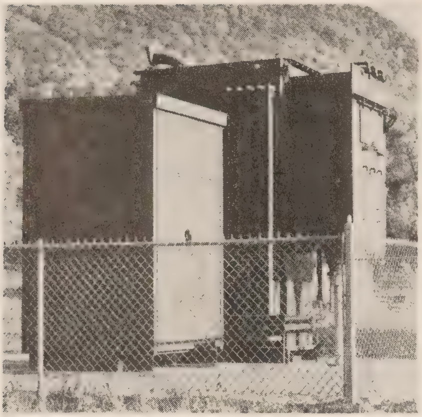


Cut No. 14—Arrangements for primary network distribution.

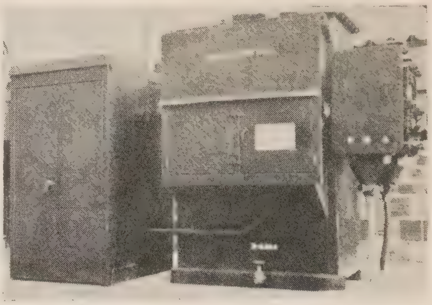
Another arrangement which has recently gone into service, and which is similar to schemes shown in Figs. 5 and 7 in that it permits an incremental addition of substation capacity, is shown in Fig. 8. This scheme utilizes the latest idea in factory built or power protected transformer already referred to.

As may be noted in Fig. 8, one power protected transformer is made to serve as a spare unit by means of a transfer bus. All disconnecting switches are externally mounted and the power protected transformer is serviced as a complete assembly. The whole unit is taken out of service to repair or inspect any major part of it. The use of a protected transformer of this type in the correct form of distribution system appears to have some merit. The economics of this application have already been referred to.

Substations for primary network distribution are shown in Figs. 9, 10 and 11, Cut No. 14. The elements of the so-called primary network unit are shown in Fig. 9. The unit consists of a 3 phase transformer of about 1500 kv-a. capacity, a transformer circuit breaker and four feeder circuit breakers. The transformer circuit breaker is equipped with a directional relay for transformer faults or high side line faults and with a long time overload relay for bus faults. It usually is equipped with an automatic reclosing relay which reloses when the primary voltage is at a proper magnitude and phase rotation. The feeder circuit breakers trip on overload and are equipped for adjustable time multiple reclosing. The four feeder unit is considered standard for networks since four outgoing ties are necessary to form a symmetrical type of checker-board network. Very few primary networks take this symmetrical form, however, and many network units have only two or three feeder



Cut No. 15—Single feeder unit substation, 750 kv-a.



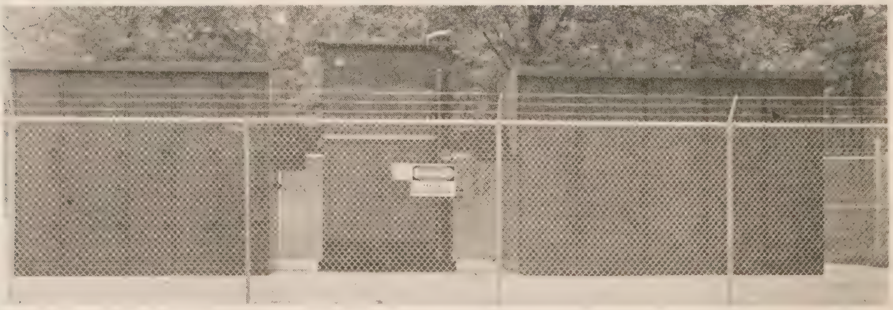
Cut No. 17—A 1,000 kv-a. single unit substation, disconnecting and grounding switches on side of transformer.

positions. Fig. 10 shows the simplest form of primary network with two units tied together through two ties and each unit serving a radial feeder separately.

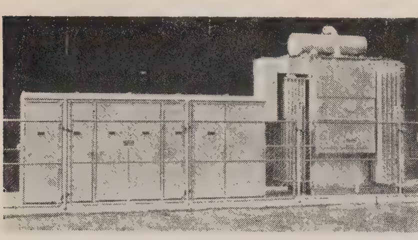
Primary networks are frequently started by the installation of a single factory built unit substation to be tied in with an existing radial substation of conventional design. Frequently this procedure is found to be the most economical means of relieving overloaded feeders in the large radial substation. A small unit substation is installed near the centre of load sectionalizing several feeders and feeding their extremities radially. This arrangement is shown diagramatically in Fig. 11, Cut No. 14, indicating the method whereby a primary network may be started and additional units may be added later to strengthen the network as the load increases.

The photographic cuts shown illustrate actual installations and give you a very good idea of how these unit substations look after erection or should I say after the delivery of the package.

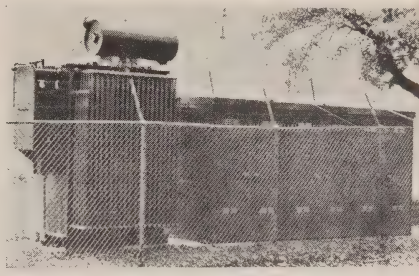
Cut No. 15 illustrates a 750 kv-a. single feeder substation of the type



Cut No. 16—A unit substation rated 3,000 kv-a.



Cut No. 18—A 3,000 kv-a. unit substation designed for network operation.



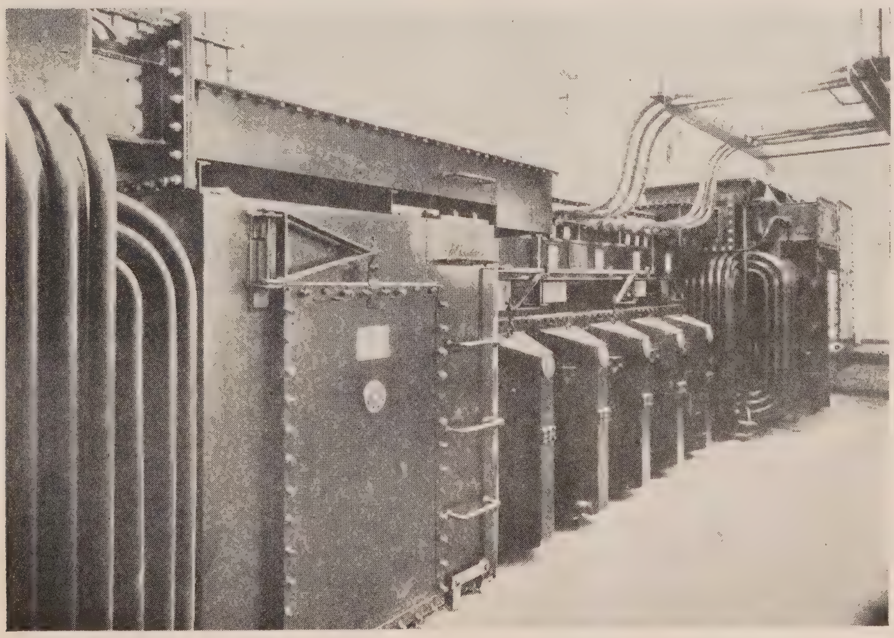
Cut No. 19—A unit for network operation tied in with a large conventional substation.

shown in Fig. 1, Cut No. 13. This unit is for rural radial distribution.

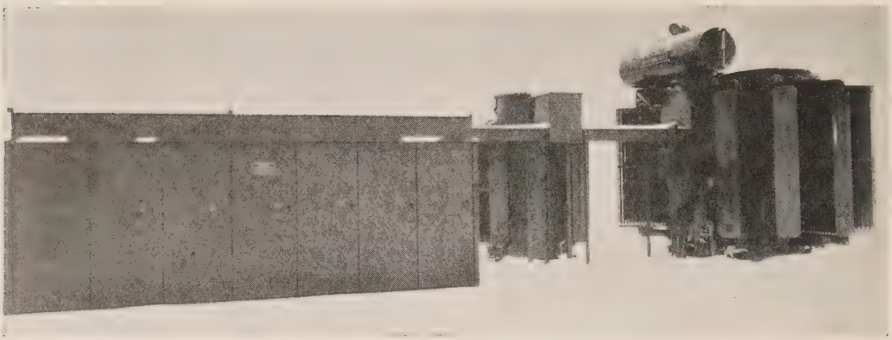
Cut No. 16 illustrates a unit substation similar to the type shown in Fig. 4, Cut No. 13. This installation is rated at 3000 kv-a. and is used for radial distribution.

Cut No. 17 illustrates a 1000 kv-a. single feeder unit substation of the type shown in Fig. 6, Cut No. 13. The unit is characterized by two 13 kv. oil-immersed disconnecting and grounding switches mounted on the side of the transformer.

Cut No. 18 illustrates a 3000 kv-a. substation designed for network operation. It is equipped with four feeder circuit breakers and one transformer



Cut No. 20—A double transformer subway type installation.



Cut No. 21—Outside unit substation at Ottawa, control switchboard is installed in adjacent old substation building.

circuit breaker, as indicated diagramatically in Fig. 9, Cut No. 14.

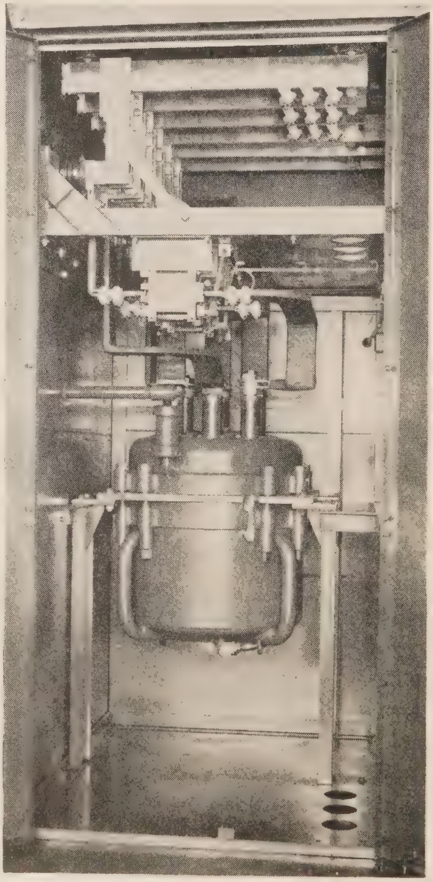
Cut No. 19 is a unit designed for network operation and is tied in with a large conventional substation with an arrangement similar to that shown in Fig. 11, Cut No. 14.

Cut No. 20 illustrates a double transformer installation similar to the arrangement shown in Fig. 5, Cut No. 13. This particular unit is of the subway type for installation in an underground vault.

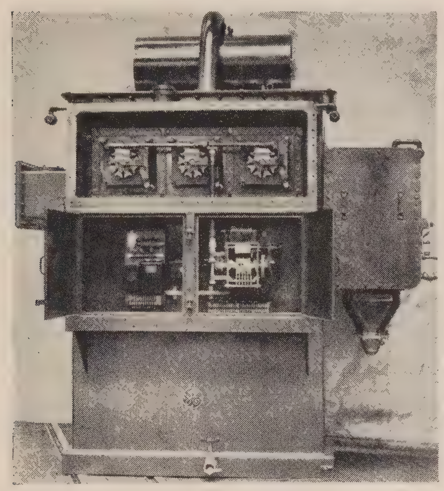
Cut No. 21 illustrates the outdoor unit substation of the Ottawa Electric Co. on Nelson St., where the transformer, regulator and switching equipment is mounted outdoors as a unit and advantage is taken of an old substation building to install the control switchboard, etc. A similar substation is also installed by the same company at Holmwood Ave.

Cut No. 22 illustrates the interior of a 2400 v. outdoor breaker compartment in a typical unit substation.

Cut No. 23 is a shop photo of a typical three phase transformer unit, 13 kv./2400 v., 1250 kv-a. The load ratio



Cut No. 22—Interior of a 2,400 v. outdoor breaker compartment.



Cut No. 23 — A typical three phase transformer unit 13,000/2,400 v., 1,250 kv-a.

side compartments are open. Note the 13 kv. cable terminal connection pothead on the right and the throat for the low potential connections on the left.

The foregoing examples illustrate Canadian and American unit substations for distribution use. The British examples of somewhat similar unit substations are shown in Cuts Nos. 24, 25, 26 and 27. Our British relatives refer to these units as Kiosk substations.

Cut No. 24 (illustration omitted) shows a general view of Ludborough Kiosk substation housing three 400 ampere, 22 kv. panels, two 11 kv. panels, etc., and one 1000 kv-a. transformer.

Cut No. 26 is an end view of the Kiosk with the doors of the low voltage compartment open.

Cut No. 27 (illustration omitted) is interesting in illustrating a small

Cut No. 26—End view of an English Kiosk with door of low voltage compartment open.

Kiosk substation of the Kent Electric Power Co. mounted on one side of a thoroughfare in England. Note the absence of overhead wires either for telephone or power service, but the presence of a public pay telephone booth—or perhaps it too is a Kiosk.

The use of metal-clad unit assemblies is, of course, not confined to distribution substations either on this continent or in Europe. A great amount of metal-clad equipment has been furnished for terminal stations at transmission line potential.

Cut No. 28 (illustration omitted) is a general view of a British terminal station of 132 kv. Note the cable entrances to the metal-clad and to the transmission line tower. The Provincial Commission has several examples of metal-clad unit assemblies at its terminal and generating stations with which most of you are familiar.

The metal-clad idea originated, I think, in the Old Country—certainly the gum-filled idea. Canadian manufacturers were not long in recognizing its advantages and applying the idea to our conditions in this country.

I must acknowledge here and thank

the manufacturing companies, particularly the Canadian General Electric, the Canadian Westinghouse Co. and the Northern Electric Co. for a great portion of the descriptive data contained in this talk on unit substations for distribution work. The manufacturers, it would appear, have done a characteristically good job in the design, fabrication and assembly of these unit substations. I hope that none of us will order these units as we would groceries or "ring" distribution transformers without regard to the use to which they are to be put and the characteristics of our local municipal systems.

Municipal engineers must do the application engineering in selecting unit substations as in all other divisions of their work or we will have poor arrangements of quite suitable equipment or good arrangements of quite unsuitable equipment.

The Winter Convention

IN the February issue of this publication and also in this number are some of the papers, addresses and reports given at the winter convention of the Ontario Municipal Electric Association and the Association of Municipal Electrical Utilities which was held at Toronto on February 6th and 7th, 1940. Two addresses of especial significance given at joint sessions of the two associations were that by Dr. T. H. Hogg, Chairman of the Hydro-Electric Power Commision of Ontario on "Hydro and the War" and one by E. V. Buchanan, General Manager of the Public Utilities Commission, London, Ontario, on "Public Relations". Both these addresses appeared in the February issue. The paper presented by C. H. Hutton, Chief Engineer of the Hamilton Hydro-Electric System, "An Outline of Unit Substations for Distribution Systems", is published in this and the preceding issue. John Dibblee, Assistant Chief Engineer of The Hydro-Electric Power Commission, gave an illustrated address entitled "Destructive Forces, Damage and Repairs". Mr. Dibblee showed the damage done to plant at various times by the action of ice, water and wind and also resulting from accidents at various times on parts of the Commission's systems. It was a convincing demonstration of serious failures that are liable to occur which the engineers must be prepared to meet at all times and to devise methods of preventing their recurrence.

The 1940 summer convention of the two associations will be held at Bigwin Inn, Muskoka, on July 9th and 10th.

* * * *

O.M.E.A.

During the O.M.E.A. sessions of the convention the following resolutions of general interest were adopted.

Re Additions to Hydro Building

That this association go on record as recognizing the very serious shortage of office space for the efficient administration of the Provincial Commission, and being in favour of the proposal for the construction of additional storeys upon the present new building at such time as the Provincial Commission may deem advisable.

Re Constitution and By-Laws

That our Constitution be amended by adding under section dealing with the subject of Committees, the following clause:—

(3) Legislative Committee (consisting of three members).

It shall be the duty of the Legislative Committee to keep in close touch with all proposed and pending federal and provincial legislation affecting in any way the affairs of this Association.

The Committee shall consider such legislation and report the effects of same to the Executive for such action as the Executive may deem necessary.

Re Undertakings Required by the Power Controller for War Purposes.

That this Association request the Power Controller appointed by the Federal Government to give the Provincial Hydro Commission the same treatment under similar conditions as private companies, in connection with undertakings required by the Power Controller for War Purposes.

Officers elected for 1940 are as follows:—

Honorary-President:—Dr. T. H. Hogg, Chairman, H.E.P.C. of Ontario.

Honorary - Vice-Presidents:—F. C. Elliott, Ingersoll; T. A. McFarland, London; Jos. Gibbons, Toronto; F. Biette, Chatham; G. S. Matthews, Peterborough; C. J. Halliday, Chesley.

President:—Dr. W. J. Chapman, St. Catharines.

Vice-Presidents:—

District No. 1—W. R. Strike, Bowmanville.

District No. 2—John Kalte, Hanover.

District No. 3—Sam Ashton, Port Arthur.

District No. 4—K. A. Christie, K.C., Toronto.

District No. 5—Keith McLeod, Stamford Centre.

District No. 6—E. L. Box, Seaforth.

District No. 7—P. R. Locke, St. Thomas.

District No. 8—Garnet Edwards, Windsor.

Secretary-Treasurer:—T. J. Hannigan, Guelph.

* * * *

A.M.E.U.

Of the A.M.E.U. Committee reports, given elsewhere in this issue, all were adopted excepting that by the Rates Committee. There was a diversity of opinion regarding the recommendations given in that report and it was, therefore, referred back to the Committee for further consideration. During the discussion on the Merchandising Committee report a resolution was adopted extending to The Hydro-Electric Power Commission of Ontario the appreciation of the members for the wonder-

ful work done in the municipalities by the Lighting Service Section of the Sales Promotion Department.

The following officers were elected for the year 1940:—

President:—A. B. Manson, Stratford.

Vice-President:—C. E. Brown, Meaford.

Secretary:—S. R. A. Clement, H.E.P.C. of Ontario, Toronto.

Treasurer:—George E. Conn, H.E. P.C. of Ontario, Toronto.

Directors (from the Membership at Large):—A. W. Bradt, Hamilton; S. W. Canniff, Ottawa; W. R. Catton, Brantford.

District Directors:—

Niagara District—O. M. Perry, Windsor.

Georgian Bay District—R. S. King, Midland.

Central District—G. F. Shreve, Oshawa.

Eastern District—R. J. Smith, Perth.

Northern District—R. H. Martindale, Sudbury.

Standing Committees for the year were drafted at a meeting of the Executive Committee held during the convention as follows:—

Papers Committee:—A. W. Bradt, Hamilton, Chairman; J. W. Peart, St. Thomas, C. E. Schwenger, Toronto; G. E. Chase, Bowmanville; C. W. Hookway, Canadian Westinghouse Company, Toronto; H. D. Rothwell and M. J. McHenry, H.E.P.C. of Ontario, Toronto.

Convention Committee: — C. E. Brown, Meaford, Chairman; J. E. B. Phelps, Sarnia; O. H. Scott, Belleville; F. Mahoney, Canadian General Electric Co., Toronto; E. G. McCracken, Sangamo Company, Toronto; W. R. Greenshields, Canada Wire and Cable Co., Toronto; W. Dixon, Canadian Westinghouse Co., Toronto; W. N. Elliott, N. Slater Co., Hamilton; G. F. Drewry and B. Mulholland, H.E.P.C. of Ontario, Toronto.

Regulations and Standards Committee:—S. W. Canniff, Ottawa, Chairman; P. B. Yates, St. Catharines; O. H. Scott, Belleville; M. W. Rogers, Carleton Place; F. D. Hubbell, Windsor; F. W. Peasnell, Toronto; R. L. Dobbin, Peterborough; J. Eckersly, Toronto; C. McGhie, Welland, and A. G. Hall, H.E.P.C. of Ontario, Toronto.

Committee on Accident Prevention and Health Promotion:—R. J. Smith, Perth, Chairman; P. B. Yates, St. Catharines; J. E. B. Phelps, Sarnia; C. E. Schwenger, Toronto; J. W. Peart, St. Thomas; R. Harrison, Scarborough Twp.; V. A. McKillop, London; F. D. Hubbell, Windsor; R. L. Dobbin, Peterborough; A. B. Manson, Stratford; A. W. Murdock, B. Mulholland, V. A. Beacock and Wills Maclachlan, H.E.P.C. of Ontario, Toronto.

Merchandising Committee:—O. M. Perry, Windsor, Chairman; O. H. Scott, Belleville; R. W. Turner, Hamilton; R. S. Reynolds, Chatham; H. R. Hatcher, Galt; A. W. J. Stewart, Toronto; O. C. Thal, Kitchener; F. Wilkinson, London; E. Parsons, Sarnia; N. Robinson, Stratford; S. W. Canniff, Ottawa; R. L. Dobbin, Peterborough; J. W. Peart, St. Thomas; F. S. Rhoads, Windsor; J. J. Jeffery, W. Dymond and M. J. McHenry, H.E.P.C. of Ontario, Toronto.

Rates Committee:—W. R. Catton, Brantford, Chairman; A. B. Manson, Stratford; G. E. Chase, Bowmanville; P. B. Yates, St. Catharines; O. H. Scott, Belleville; O. M. Perry, Windsor; R. S. Reynolds, Chatham; T. R. C. Flint and F. W. Peasnell, Toronto; R. B. Chandler, Port Arthur; J. J. Jeffery, G. F. Drewry and S. R. A. Clement, H.E.P.C. of Ontario, Toronto.

Committee on Accounting and Office Administration:—R. S. King, Midland, Chairman; George Appleton, Toronto, Vice-Chairman; H. R. Hatcher, Galt; T. W. Houtby, Welland; A. B. Manson, Stratford; J. W. Hammond, Hamilton; W. E. Wallace, Windsor; M. A. Gough, East York Twp.; C. W. Eastwood, London; P. E. Battram, Sarnia; A. M. Bowman, Elmira; A. E. Ditchburn, Strathroy; W. M. Salter, Barrie; R. C. Parker, Penetanguishene; R. H. Martyn, Ripley; G. W. Grabb, Chesley; M. W. Rogers, Carleton Place; H. Clegg, Peterborough; A. D. Nelson, Kingston; O. H. Scott, Belleville; Wm. Tait, Picton; R. H. Martindale, Sudbury and R. M. Bond, H.E.P.C. of Ontario, Toronto.

Auditors:—H. P. L. Hillman, Toronto, and W. G. Pierdon, H.E.P.C. of Ontario, Toronto.

Finland's Electric Power

Very little was heard of Finland until the present invasion by Russia, mention of such places as Helsinki and Viborg would only have evoked a look of interrogation on most faces before last November. There are thousands of lakes in the country, but the largest of them stands at a height of only 100 metres above sea level, so that the hydro-electric power available is far less than it is in the mountainous regions of Norway, Sweden, Italy, and France. Nevertheless, the large acreage of water ensures great natural storage and evens the flow throughout the whole year. Ice is a great difficulty, but Finnish engineers know how to cope with it much as Canadian experts do. Up to April, 1938, there were no less than 300 hydro-electric plants at work, developing altogether some 600,000 h.p., which is about a quarter of the total available. Half of this is produced by the two largest stations at Imatra and Rouhiala. Imatra started running in 1929 with three turbo sets of 27,000 h.p. each, and later it added another 27,000 h.p. and two of more than 32,000 h.p. each, the present capacity being assessed at 172,000 h.p. Rouhiala has a total horsepower of 132,000. Another station of 94,000 h.p. was being erected at Harjavalta in 1938. At first the bulk of the water power was used for electric lighting and for the ironworks, but more recently the mechanical wood pulp mills use about ten times as much hydro-electric power as that consumed for all other purposes put together.—*The Electrical Times.*

A.M.E.U. Committee Reports

Report of Regulations and Standards Committee

The Regulations and Standards Committee met in Toronto, on Friday afternoon, November 10, 1939.

Three matters had been referred to it by the Convention of the Association on February 7, 1939, for consideration, and this meeting was called for the purpose of discussing these questions, with results as follows:

(1) "That the standard rating of induction motors be changed from 550 volts to 575 volts, three-phase."

It is the opinion of this committee that no action be taken to disturb the present rating, it being considered that any unfavorable voltage not suitable for this rating is a condition to be adjusted by the local utility.

Mention was made of the fact that the Canadian Electrical Code tables are based on 550 volt and if any change were made, it would also be applicable to the 110, 220, and 440 volt ratings to keep these in the same relative position, (C.E. Code 1939. Tables XXII, XXIII and XXV).

The above was fully discussed and the motion carried, unanimously.

The Committee's recommendation is therefore that no action be taken to change the present rating.

(2) "That manufacturers be asked to standardize on the 1,000 watt scale on 5 ampere meters, some of which are supplied with 1,500 watt scales."

A resolution was moved and seconded, that the 1,500 w. scale is more suitable in the majority of instances and that the 1,000 w. scale is obtainable, if required.

This was discussed fully and the motion carried, all being in favor.

The Committee's recommendation is therefore against the suggested standardizing of the 1,000 watt scale.

(3) "That manufacturers propose standardizing on 15 ampere, 220 volt, 3 wire meters and discontinue the 25 ampere."

The opinion of the committee was that in view of the load building programme of the Hydro-Electric Power Commission of Ontario, it is not desirable to discontinue the 25 ampere meter.

The above was fully discussed and the motion covering it was carried unanimously.

The Committee's recommendation is therefore that the 25 ampere meter be continued.

Signed on behalf of the Committee,

C. E. BROWN,
Chairman.

* * * *

Report of the Merchandising Committee

A meeting of the Merchandising Committee was called on December 8th to discuss various problems in connection with merchandising and promotional work.

Mr. McHenry outlined the operations of the Sales Promotion Depart-

ment during 1939, especially the industrial and commercial activity, domestic and rural, and the Lighting Service Section operations, also giving a brief resume of the nature of the Advertising Campaign as carried on throughout the year, outlining the coverage obtained by the various media used.

The increase in the number of municipalities assisting in part or whole in the installation of a range wiring service was drawn to the Committee's attention, along with the estimated number of 11,000 ranges having been sold in the province for the year.

The Rural Travel Shop operations were explained in some detail. The 76 municipalities covered entailed some 3,460 miles of travel, along with an estimated attendance of 57,000 at these various meetings which gave the Committee an indication of the importance and the accomplishments of this operation.

Mr. G. G. Cousins gave a brief outline of the Lighting Service Section's activity and stated that some 1,524 power users have been called upon, with a total of 604 lighting recommendations furnished. The recommendations were submitted in over 186 municipalities: 79 demonstration installations were made and 30 lectures were given. Mr. Cousins stressed the work of the Department in bringing to the attention of commercial users the advantages of using power in the follow-up rate, especially as applied to lighting. A new publication shortly to be issued entitled "39 Steps to Better Business" was shown to the Committee and its purpose explained.

Mr. Cousins expressed his appreciation of the co-operation received from municipalities and although the nature of their work, owing to war conditions has necessarily been somewhat curtailed in the domestic field, and their attention directed more to industrial lighting activity, he assured the members that the Department was now in the position to take care of all reasonable requests for lighting service.

The history of the $3.00 range allowance was reviewed and it was pointed out that the allowance had been given to further the advertising and promoting of the sale of ranges. It was felt that the allowance had not been utilized for the purpose intended and therefore it was deemed wise to terminate it. A new promotional effort has been decided on which it is hoped will bring more beneficial returns for the money expended.

Considerable discussion followed regarding range financing as to the experiences of the various municipalities in dealer financing and Hydro Shop financing. The rates of interest, term of years, trade in allowances on old equipment and bonuses varied considerably, as well as the nature of contract under which the various dealers signed with the local Hydros, and the Committee came to the conclusion that no definite set policy applicable to the province as a whole could be formulated.

Mr. McHenry briefly outlined two proposals submitted by a finance company covering Time Payment Plans for major appliances. No action was taken in this regard. It was forcibly brought to the Committee's attention

that a relatively small amount of capital is necessary to carry on a Time Payment Scheme, and with an average interest rate of 4½ per cent it seemed possible to successfully take care of all the contingencies met with in appliance financing.

One municipality does not charge the same rate of interest on all appliances. Free service is limited to heavy current consuming appliances such as ranges, irons, toasters, etc. Other appliances such as refrigerators, washing machines etc. are serviced at a nominal rate per hour for labor, the material used in all cases being charged for.

The practice of giving premiums or gifts was discussed at some length and it was generally agreed that as Hydro Shops had not participated in any way in this regard, this merchandising idea should not be indulged in.

It was pointed out that in some places the gas refrigerator outlets were becoming quite active and competition could be expected.

The financing contract between the dealer and the utility came in for considerable discussion.

One municipality charges 5 per cent to dealers and assumes all responsibilities for servicing and collections.

Another municipality, after a complete check of range and the conditions on consumer's premises, as well as the credit rating of the consumer, will finance dealer sales, but holds the dealer responsible for service for one year after date of contract similar to responsibilities accepted under manufacturer's guarantee.

Another municipality holds back 10 per cent of the sale price for three months.

One utility handles the complete transaction for the dealer, paying the range supplier and collecting from the customer, the dealer receiving 20 per cent of the value of the sale.

Allowances for old equipment varied considerably. The maximum period of 3 years for range financing seemed to be general.

One utility financed ranges at 5 per cent, appliances 7 per cent and 4 per cent on ranges sold to rural consumers.

Another utility quotes an all inclusive price on all major merchandise, including interest and financing charges, the quoted price varying with the term of years under which the appliance is to be financed.

The Committee recommends that all municipalities finance both dealer and Hydro range sales and that it is advisable to have some schedule of trade-in allowance for obsolete equipment in effect.

Some comparative figures were then supplied the Committee regarding the new gas flat rate water heater as compared with the Hydro flat rate scheme, and it was shown conclusively that the Hydro plan and rates still offer the consumer the more advantageous and economical way of securing a supply of hot water.

Mr. Dymond gave a short outline of the Hydro lamp sales for the year, giving the number of municipalities now making available Hydro long life lamps to their consumers, and drawing to the Committee's attention the remarkable increase in the sale of higher wattage lamps, one of the large

sizes having an increase of over 400 per cent, although the average for the low wattage lamps (15 to 100 watt) is approximately 30 per cent. The assistance given to the municipalities in respect to display advertising, direct mailing pieces, in the form of blotters and merchandising display stands, was covered, along with mention of the 1940 newspaper lamp advertising plans.

Mr. Cousins then reviewed to the Committee the reason for the 1,500 hour long life lamps and showed how with cheap power rates in Ontario and lamp costs, this was a very economical and desirable life. The Committee recommends that the policy of supplying 1500 hour lamps to Hydro specifications by The Hydro-Electric Power Commission for the municipalities be re-endorsed.

The Committee then discussed at some length how lighting reports produced by the Commission's Lighting Service Section should be presented to the consumers requesting same, and it is recommended that the matter be left to the individual utility manager to signify to the Lighting Service Section just how he would like these reports transmitted.

Mr. McHenry then discussed the problem presented when municipalities request the Department to advise them regarding opening Hydro Shops, especially as it applies to the smaller municipalities, and the Committee was of the opinion that no municipality is too small to have a shop or office suitable for the sale of or servicing of consumers' appliances. The Committee feels that every utility should be actively engaged in merchandising and promotional work, in full co-operation with the local electrical dealers.

An outline of the 1940 program similar to the preview given in the December issue of Ad-Watts was submitted. It covered the industrial promotion plans, especially as they would be applied to war time industrial effort. Domestic and rural promotion plans, although curtailed to some extent for the coming year, will be maintained, and with the addition of the Hydro Homemakers' Club it is expected that this section of the Department's activity will be adequately taken care of.

The Commission's advertising program was also fully outlined and the coverage expected graphically depicted. The addition of weekly newspapers to the Commission's advertising media was announced.

Mr. George Hague of the MacLaren Advertising Company presented sketches of some of the forthcoming advertising material to appear in periodicals and newspapers, both daily and weekly, and some constructive criticism was expressed by the Committee.

The Committee endorses the past activities of the H.E.P.C. Sales Promotion Department and expresses approval of the program outlined for 1940 and hopes that all Commissions will co-operate to the fullest extent.

Signed on behalf of the Committee,

O. H. SCOTT,
Chairman.

* * * *

Report of Rates Committee

The A. M. E. U. Rates Committee held three meetings during the year, one in Brantford in June and two in Toronto, one in November and one in December. Matters considered by the Committee are as given below.

Flat Rate Water Heaters

Suggestions had been received of giving an extra discount when flat rate water heaters are controlled. By controlling this load power would be made available for other purposes as also distribution system and line transformers. Against such saving there is the expense of installing the control system. The Committee made the following suggestion:—

When the flat rate water heater load in a municipality is controlled in whole or in part, that the rates to all flat rate water heaters in the municipality be made uniform, i.e. there will be no distinction as far as rates are concerned, whether the heaters are controlled or not. The suggestion of using extra discounts is not considered desirable. Where the tank is installed the rental for the tank should be added to and included in the rate.

In municipalities where the flat rate water heaters are controlled, 25 per cent should be deducted from the kilowatt-hours used for the purpose of splitting costs for system analysis.

For the purpose of system analysis, the cost of installing flat rate water heater control should be charged to the whole system and split on demand.

Re 75 Per Cent of Demand Rule

The suggestion was made at the 1939 Summer Convention that the present ruling for decreased load of billing on the basis of not lower than 75 per cent of the previously established maximum demand be considered to ascertain if this limit could not be lowered. This was referred to The Hydro-Electric Power Commission of Ontario whose Rates Committee advised that, since with the present 75 per cent limit the net revenue from service charge without considering class or local discounts became 67.5 cents per horsepower per month of the previously established maximum demand, it did not consider a reduction of the present limits desirable, when compared with the cost of the service. A concession might be made, however, while retaining the present limit of 75 per cent applying to the service charge by dividing the kilowatt-hours on the basis of actual demand. This Committee accepted the Commission's suggestion and asked that the clauses of the Standard Interpretations of Rates be rewritten accordingly, this change to apply to power users only, commercial lighting service to remain unchanged.

Neon Signs

Attention was directed towards the lack of uniformity in marking Neon signs to show their rating, and also to the present rulings governing billing for them. The Hydro-Electric Power Commission was asked to take steps towards having a uniform method of labelling the signs in an accessible location and also to consider rewriting the rules for billing these signs, taking in fluorescent lighting. The Commission's Rates Committee advised that the matter of labelling Neon signs had been discussed with

the Electrical Inspection Department and instructions had been given to that department to establish a uniform method of labelling them giving the rating in amperes and volts, the label to be placed in an accessible location. The Commission's Committee recommended that no change be made in the wording of the present rules for billing. This report was accepted by this Committee.

SMALL LOADS, INTERMITTENT LOADS AND ELEVATOR MOTORS

The question was brought up as to the intent of the rules for billing for small power loads and for intermittent loads, referring to Clauses 45, 46 and 47 of the Standard Interpretations of Rates. The Hydro-Electric Power Commission of Ontario was asked to reword these clauses so as to clarify the intended meaning. The Commission's Rates Committee submitted a suggested revision for Clause 45, "Service to Small Loads" which was amended slightly and accepted. The proposed new Clause 45 is:—

"Unless a polyphase street main at motor voltage passes the consumer's premises, installations of less than 5 horsepower will be given single-phase service. If polyphase service is required by the consumer for less than 5 horsepower, and it is not already available from existing polyphase street mains, such load may be billed on a minimum of 5 horsepower".

The Commission's Rates Committee submitted a suggested rewording of Clauses 46 and 47, "Intermittent Rated Equipment" and "Elevator Motors" which endeavoured to clarify the intention of these two clauses. The suggestion was accepted for application except in municipalities where there are special conditions and the Commission was asked to write the clauses in their final form.

In order that there will be no misunderstanding as to the capacity of intermittent rated equipment the Hydro-Electric Power Commission was asked to take steps to have all such equipment supplied with nameplates, put on by the manufacturers, showing the rating as "intermittent".

Signed on behalf of the Committee,

W. R. CATTON,
Chairman.

* * * *

Report of the Committee on Accounting and Office Administration

The Committee on Accounting and Office Administration held two meetings during the year for the purpose of transacting the general business. These meetings were well attended and considerable interest was in evidence in respect to the affairs of the Committee.

In addition the following special meetings were held under the direction of the Committee:

(1) A regional meeting at Barrie on the 14th of June, 1939, at which fifty-one were present from the Georgian Bay system along with representatives of office equipment manufacturing companies and six from The Hydro-Electric Power Commission of Ontario. This meeting was similar to former regional meetings held in

other parts of the province for the purpose of giving those in attendance an opportunity of discussing accounting methods and viewing up-to-date office equipment. The plan of commencing the meeting in the morning and continuing until late afternoon with an adjournment for luncheon was followed and met with approval. His Worship, the Mayor of Barrie, addressed the luncheon meeting and welcomed those present and expressed the appreciation of the local commission of the accounting methods in operation in the electric department.

(2) A sub-committee meeting was held in London with representatives from the western section which has been organized as a unit under the chairmanship of Mr. W. E. Wallace of Windsor. Plans were made at this meeting for a regional meeting to be held in London on September 27, 1939, and the necessary committees were named for the purpose of carrying through this meeting. Unfortunately, circumstances arose at the time arranged for the meeting in respect to the imposition of the Dominion War Revenue Sales Tax on electric service and this meeting had to be postponed. It is planned, however, that it will be held early in 1940.

The regular meeting of the Standing Committee is being arranged to be held during the Winter Convention and a sub-committee on arrangements has been appointed.

The Committee records with regret the death of Mr. W. G. Henderson of Cobourg who was Chairman of the Committee in 1938 and at the time of his death was the Chairman of the sub-committee on Legislation. The late Mr. Henderson was keenly interested in the activities of the Standing Committee and his counsel will be greatly missed. He passed away on Monday, May 1, 1939.

Signed on behalf of the Committee.

H. R. HATCHER,
Chairman.

Alexander power development with spillway discharge.

THE
BULLETIN

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Windsor Hydro Essay Contest

DURING the month of February, the Hydro Division of the Windsor Utilities Commission sponsored a Hydro Essay Contest in which $250.00 in prizes was offered to 4th and 5th Form pupils in the four Collegiate Institutes, the Windsor-Walkerville Vocational School and the equivalent grades in Assumption High School. Last year a similar contest was held which proved so successful that it was decided to have a second contest this year. Fifty-four prizes were awarded this year as follows:

1st Prize	$50.00	
2nd Prize	25.00	
3rd Prize	15.00	
4th Prize	10.00	
Next 10 Prizes	5.00	each
Next 20 Prizes	3.00	"
Next 20 Prizes	2.00	"

In addition there was a prize of $25.00 given to the school having the largest percentage of entrants.

The subject for the contest was "Hydro in the Home" and essays were to be approximately 1,000 words. No pupil having a member of his family in the employ of the Windsor Utilities Commission was eligible to enter the contest. Entries were judged on the following points:

(a) Knowledge and command of subject.

(b) Originality of treatment.

(c) Accuracy.

(d) Spelling.

(e) Writing.

(f) Literary qualities.

Out of 1,542 students who were eligible, 905 submitted essays. Upon receipt of the essays they were given a preliminary reading. Average essays were graded "B", less than average "C" and better than average "A". This resulted in 57 being graded "A"; 658 as "B"; and 190 as "C". Three judges then re-read the "A" essays, marking each and allowing 60 points for knowledge, 30 for literary qualities and originality and 10 for spelling and writing. The 54 prizes were determined on this basis, and the cheques were given out in the School

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April, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

Assemblies at which there were more than 3,000 pupils present.

The Windsor Utilities is greatly pleased with the response received and the keen interest shown. The contest has created a high degree of publicity.

The first prize of $50.00 was won by Audrey Gask of the Windsor Vocational School. Her essay is reproduced below:

Hydro In The Home

By Audrey Gask, Windsor Vocational School

Many are the songs and poems written in praise of "home", bespeaking its comforts and contentment. From earliest times when man sought seclusion and peace around a brightly burning fire in his dismal and draughty cave, to the present day when we sit cosily in our scientifically lighted rooms, the home has been the core of the nation—the deciding factor whether the nation should rise or fall. From contented, well-managed homes rise successful, civilized nations.

All praise and credit must be given to those factors which contribute to the smooth, efficient management of a home—those factors which make home a happier, more comfortable place. Without one moment's hesitation, then, we award the laurels to "Hydro"—that silent but most efficient server of mankind.

Clear in my mind is the memory of my home in England ten years ago in which the liberating hand of Hydro had not performed its miraculous tasks. I can recall my mother, with minute precaution, turning out the oil lamp at night and gingerly casting moist tea leaves over the carpet preparatory to cleaning. Likewise, too, my visions reveal to me rows of burnished brown tea-cakes and golden bread, spread appetizingly upon a table in an over-heated kitchen. How delighted I was to do my part in consuming such excellent cookery, little realizing the time my mother had spent in its preparation—the tedious piling of wood to heat the oven, the caution taken to acquire the exact amount of heat and the patient watching lest the labor of her hands might burn.

What a wonderful world was mine when we took up residence in our Canadian home—the magic power that

lay behind a simple switch. The luxury of a bed lamp astounded me, and the rosy glow of a toaster upon the breakfast table in the morning was the cause for extreme delight. One evening just after our arrival, I returned home to find my mother in deep exasperation at my father. "How can I get a dinner ready when he hasn't left a match in the house to light the stove with?" she bewailed. Dinner was lacking that evening, true, but our merriment over mother's disregard (I should say unfamiliarity) of a magic switch was adequate compensation.

Hydro in the home today is the unseen helpmate of busy house managers. The labor saved by its power is immeasurable. No longer are tea leaves whisked over our carpets to catch the dust. The mere snapping of a button sends intricate machinery awhirr and our carpets are renewed and refreshed. Time was when the weekly wash was a solemn ceremony of steaming kettles and loathsome boards and tubs. Today the woman who washes the Hydro way settles herself comfortably by the radio to listen to the latest suggestions on cookery and home management, while electricity and the washing machine settle the problem of the dirty clothes. Even after the clothes are brought in from the yard clean and fresh, the symphony of Hydro is continued through the ironer till the clothes are neatly piled ready for placing in the closet.

We are going to be a healthier breed of men because of Hydro. Our food is the foundation upon which we build healthy, energetic body. Food, then, to be of the utmost value to us must be prepared efficiently and there is no better method than the Hydro way. Modern electric stoves with their specially designed utensils and automatic oven-control, dispatch meals to our table, in which the vitamin content is retained and the exact degree of cooking has been performed to ensure easy digestion. Housekeepers who follow the advice and recipes of Hydro's dieticians can always boast that their families are fed with meals "fit for a king".

The refrigerator, too, plays a vital part in keeping us well by maintaining food at such a temperature that contamination is well-nigh impossible. Air conditioning has purified the air we breathe, thus lessening the spread of germs and the ensuing serious results. No better substitute for the sun, under the sun, can be found than the indirect lighting system afforded by tri-light lamps. Our eyes slip over the printed matter smoothly and an evening's reading under these conditions is one well spent and one in which eye strain is unthought of.

Hydro has made our lives so worth while because of its convenience. It is such a pleasure on a morning to revel in a delightful warm shower—Hydro has been faithful through the night and kept your tank hot. Then the male sex can enjoy the exhilarating feeling of an electric razor dispelling that stubborn beard. No Roman emperor with all his grandeur enjoyed a more tasty breakfast than falls to our lot with Hydro's miraculous devices. The toast pops out from its mirror-like chrome container a golden brown, your waffles, cooked to

perfection, beam at you in their crisp, checkered coats, and your coffee emerges from its crystal palace piping hot and just right! A Hydro breakfast is the best send off to a successful day. "All things come home at eventide" lilts a familiar song, and those who return to a Hydro-equipped home find true comfort and contentment. There is no need to stir abroad at night. You have the very world at your finger-tips with a radio at your side. You can loll leisurely back in your chair and listen to the story of the world being written, follow the solemn beauty of a symphony, the dramatic unfolding of an opera or well-known book, or, if in a lighter mood, tap your toes to the pulsating rhythms of an orchestra.

All Hydro's advantages would avail nothing were they the exclusive privilege of a few, but the extremely low operating cost of Hydro affords everyone a splendid opportunity to take advantage of its utility. God has endowed this wonderful country of ours with innumerable blessings and one of the most valuable is Hydro. The gigantic forces of Niagara have been marshalled with the result that, under careful supervision and management on the part of our government this God-given blessing is available to all at a minimum of cost. Hydro is yours. Use it and save.

Our civilization of today could not have reached its mark of perfection without electricity. We owe a great debt to Sir Adam Beck and all those pioneers who developed its qualities for our general good. That which contributes to the welfare and happiness of a nation as a whole is worth unending praise. We can truly say that the song of praise and thanksgiving to Hydro will ring on down through the centuries to come.

Hydro and the St. Lawrence

By Dr. Thomas H. Hogg, Chairman and Chief Engineer,
The Hydro-Electric Power Commission of Ontario

TO the average citizen of Ontario and Canada, the St. Lawrence navigation and power project is a mammoth undertaking that has periodically appeared and disappeared from his field of notice, always without finality one way or the other. He is now surprised at its re-appearance at a very critical period in Canadian history, when all our best energies are needed for a life or death war. His first question is: why would it not be best to defer any decision until after the war, when the re-establishment of returned soldiers will present a pressing social problem of great magnitude? He has noted with disquiet and alarm a great deal of anti-St. Lawrence propaganda warning him that it would saddle Canada with an enormous expense, running into many hundreds of millions of dollars. He is being told that the navigation project would be of little or no value and that Ontario has no need, either now or in the near future, for St. Lawrence power. Yet he knows that his Government has seriously considered entering into a St. Lawrence treaty with the United States. In the face of all this, is it any wonder that he stands bewildered and more than a little suspicious?

All my life I have been interested in power, the development of power and the power needs of communities. My primary interest in the St. Lawrence project is due to power. You will know how to take this into account as you listen to what I say. But do not forget that you too have a deep interest in the project. It concerns you vitally, both as it directly affects your local interests and as it affects the interests of Canada. Moreover, as Canadians, you need offer no apology for urging that Ontario's interests be very carefully considered and for insisting upon the importance of a proper understanding of all aspects of the St. Lawrence project.

In some respects it is unfortunate that the official arguments in favor of the St. Lawrence project have not been put forward and cannot yet be put forward. For reasons which you can readily appreciate, the Dominion Government has necessarily kept silent and you have been dependent upon various analyses published by the newspapers and periodicals, very largely based upon proposals made in 1932.

On the other hand, those who take a narrow and selfish view and those who fear that their interests may be adversely affected have been loud and persistent in their clamour against the St. Lawrence project. Large sums of money have been spent for ingenious anti-St. Lawrence publicity. Although plausible, much of this deceptive propaganda collapses like a pricked balloon when subjected to careful study.

Address to The Empire Club of Canada at Toronto on April 11, 1940.

It is most regrettable that such propaganda appears to have been accepted in good faith and at face value by many newspapers and publications unaware of its fallacious character. In the absence of correct information it is perhaps natural that this should be so, but the distorted and erroneous conceptions which inevitably have arisen in the minds of the public in consequence of untrue propaganda is none the less harmful.

With this in mind, I have decided to talk to you about the St. Lawrence project. I have no intention of discussing navigation in any detail, although I shall make some references to the combined navigation and power project as a whole. My primary and official concern is with power, and I shall begin with a brief review of the power demand of The Hydro-Electric Power Commission, its growth and the resources available to meet future growth.

Power Resources and Requirements

During the interval between the last war and this, the increase in industrial use of electricity has been enormous. Thousands of factories have been established, technical processes have been developed, personnel has been trained, power equipment installed and a strong broad industrial base has been laid. On this broad base Ontario industry is capable of rapid expansion. But for the existence of this industrial foundation, the production of munitions and supplies vital for the war, in quantities that would have any significant effect upon the outcome, would be impossible.

Looking back to the last war, you will recall that notwithstanding the Commission's utmost efforts, a power shortage on the Niagara system occurred during 1917 and 1918. That shortage threatened to handicap vital industry at a time when the need for power was tragically urgent. It will be well to keep this in mind during this review of the resources of the Niagara system.

The outlook has changed materially since the Quebec contracts issue was settled some two years ago. Who would have thought then, when so many declared we would never need the additional Quebec power, that we would to-day seriously question the adequacy of our Niagara system resources to meet the demands upon them beyond the early fall of 1942. This may seem almost unbelievable to those who regarded the low rate of load growth during the early and middle thirties as a reliable indication of the probable increase in future power demands and who were seriously impressed by the repeated assertions during that period that the quantity of power available under the Quebec power contracts exceeded the Commission's most optimistic requirements for many years to come. I never took this view, and the facts do not support it.

First as to resources now available for growth. In December, 1939, our Niagara system power resources exceeded the demand for primary power including normal reserves by about 100,000 horsepower. In addition to this, the total quantities of power scheduled for future delivery under

our Quebec contracts, including the last block of 20,000 horsepower due in November, 1944, aggregate 140,000 horsepower. The two combined amount to 240,000 horsepower and represent the total quantity of power resources available for growth in the Niagara system while preserving a working reserve.

As evidence of load growth, consider this: from December, 1929 to 1931 during the depths of the depression there were substantial decreases in the Niagara system primary demand; from December, 1931 to 1935 small increases of less than 3 per cent per annum; from December 1935 to 1938 larger increases, in the order of 5 or 6 per cent per annum. But, in December 1939, our Niagara system primary load exceeded the peak of the previous year by 150,000 horsepower, a growth of 13 per cent. Last March (1940) the load growth over the previous March (1939) was 178,000 horsepower, over 17 per cent. A load increase of only 10 per cent per annum for two years over the primary load of December last, would mean that every resource of our Niagara system including the last block of Quebec power not due until 1944 would be needed to meet the demand for primary power as of December, 1941, while providing only a very moderate reserve for safety. Allowing for the growth of the Eastern Ontario and Georgian Bay systems which for a year or two will probably be supplied by transfer from the Niagara system, the working reserve will be wiped out entirely in December 1941.

Some of you may remember that for a period of eighteen years prior to the thirties, load increases of 10 per cent per annum were the order of the day. That such increases cannot go on forever no one doubts, but while war activity and industrial expansion continue, load increases of 10 per cent per annum would seem to be quite moderate.

Your guess as to how long the war will last is as good as mine. If it should continue for a number of years the need for substantial additional quantities of power in the very near future cannot be questioned. Considering the amazing growth in the mechanization of our military forces, the great increase in numbers and complexity of modern weapons and the consequent complete dependence of military effort upon maximum factory production, the importance of adequate power resources, especially during the war, is generally recognized as established beyond question.

After the war I look for a temporary decrease in power demand, followed in a very few years by more or less normal growth.

Chronology

It was in 1932 that the advocates of the St. Lawrence development first appeared to have success almost within their grasp. After exhaustive study by national and international engineering bodies and lengthy negotiations between representatives of the governments of the two countries, a treaty designed to provide a basis for the undertaking was signed.

The treaty provided for the orderly improvement of the river sections of the waterway from the head of the Great Lakes to Montreal harbour. It

also provided for the immediate development of the water power in the International Rapids section of the St. Lawrence river as an integral part of the comprehensive project; this International Rapids development was to have been a joint undertaking for navigation and power.

At about the same time Canada and Ontario entered into an agreement under which the power on the Canadian side was to have been developed by the Province.

When submitted to the United States Senate, the 1932 treaty failed to receive ratification. In consequence it was never formally presented to the Parliament of Canada nor was the Canada-Ontario agreement submitted to the Provincial Legislature.

During 1937 the diversion of northern waters into the Great Lakes from Long Lac and the Ogoki river, and the exclusive use by Canada of waters so diverted all along the international boundary received considerable attention and as a result the advantages of an international arrangement under which these international waters could be more effectively used to meet the needs in each country again came to the fore.

In May, 1938, Mr. Cordell Hull, Secretary of State for the United States, put forward a comprehensive proposal for the settlement of problems on the entire Great Lakes-St. Lawrence basin. Mr. Hull also submitted a draft treaty which provided, as before, for the construction of a deep waterway from lake Superior to Montreal harbour and, as before, for the development of power in the International Rapids section of the St. Lawrence river.

Toward the latter part of 1939 discussion of the Hull proposals was opened between representatives of Canada and Ontario and early in January, 1940, negotiations between Canada and the United States commenced. Although there has been a lull in these negotiations, there is no doubt that Canada and the United States are in substantial agreement and that the way to signing a new treaty is open.

In his letter to the Government of Canada (dated May 28, 1938) Mr. Cordell Hull summarized the provisions of the tentative draft treaty. "In brief," he said, "the proposed treaty would:

"(a) enable the United States to go forward immediately with the International Rapids Section link in the proposed St. Lawrence deep waterway and the incidental power development;

"(b) defer Canada's responsibility for completing its share of the waterway for a sufficient time to assure the readiness of the Ontario power market to absorb its share of the power;

"(c) provide for an international commission to develop plans and advise the two governments in a program to promote the most advantageous use of the entire Great Lakes-St. Lawrence resource;

"(d) assure the immediate undertaking under the supervision of this commission of the proposed remedial works to preserve the scenic beauty of Niagara Falls;

"(e) permit the Province of Ontario to go forward with its plans for diver-

sions from the Albany River basin into the Great Lakes and utilize such addition water for power at Niagara;

"(f) make available considerable additional Niagara power to each country for development at will; and

"(g) enable the proposed commission to proceed immediately with the preparation of comprehensive plans for more efficient use of the resources of the Niagara River."

From an engineering standpoint, the development plans are perfectly sound. They also have the material advantage of being nearly $30 million lower in cost than the plans upon which the 1932 treaty was based, while at the same time affording full protection for all the interests in the various sections of the St. Lawrence river. This saving, when equitably distributed among the four interested parties, materially benefits Ontario and Canada.

I must also draw your attention to a feature of the 1938 draft treaty which provides for the construction of remedial works for the protection of the scenic beauty of the Niagara falls and the development of additional power from the Niagara river. This significant provision makes additional Niagara power contingent upon the conclusion and ratification of a St. Lawrence waterways agreement.

COST

In the unavoidable absence of official information upon any treaty which might be signed as a result of negotiations during recent months, we have no choice but to assume that the basis for the division of cost of the St. Lawrence project would not differ materially from the basis set out in the treaty of 1932. I have already pointed out the probability that there will be a saving of some $30 million as compared with the 1932 plans, but in what follows, that saving is entirely neglected.

Bear in mind that the St. Lawrence River development is a combined navigation and power project, and that the estimates for the International Rapids section include the cost of works both for navigation and power. In the national section of the river, which lies wholly within the Province of Quebec, works for power and for navigation may be undertaken either independently, or as a combined project. Though official estimates are available for each, only those estimates for the navigation project are here referred to, since the power projects would be independent, self-liquidating undertakings.

Both the 1932 treaty and the 1938 draft treaty specified that the United States would provide funds for all undertakings in the International Rapids section, except those required for lands, rehabilitation, canals, locks, power-house superstructures and equipment in Canada. Thus the United States would assume the cost of all works in the river, including the dam, equipped to control and regulate the flow of the river, and including all dredging. This the United States was ready to do in order to equalize the cost of the project. Canada had already expended many millions of dollars on the Welland canal and elsewhere so that in order to finally arrive at an equal expenditure on the part of both nations, it was agreed that the

United States would bear the greater part of the expense in the International Rapids section and that Canada would complete the works in the purely national section in the Province of Quebec.

It might be argued, and with good reason, that on the basis of financial strength, the total population of the two countries, and the use of the canal, the United States should pay much more than Canada but I think our people as a whole would like to feel that they are pulling their own weight and are in no way indebted to a good neighbour for any more assistance than should be provided by an equal partner.

In the International Rapids section, which is estimated to cost a total of \$274 million for both navigation and power on both sides of the boundary, the actual gross out-of-pocket expenses incurred by Canada were:

a. For lands, rehabilitation, canals and locks (Federal Government)	\$22,320,000
b. For generating stations (Ontario)	\$36,930,500
	\$59,250,500

A total of \$59 million. Obviously this low cost to Canada for work actually done in the International Rapids section is due to the assumption of much larger expenditures by the United States in lieu of Canada's expenditures elsewhere. In this way Canada begins to secure the benefits of large expenditures already made, for which no return can now be secured.

Now let us distinguish between the obligations of the Federal Government of Canada and of the Government of Ontario which devolve upon The Hydro-Electric Power Commission of Ontario.

Ontario agreed to pay a fair price for the power benefits which would be derived from a dam, sluice gates for controlling and regulating the river, power-house substructures and channel improvements. As these works were provided at the expense of the United States in lieu of heavy expenditures already made by the *Canadian Federal Government* it was only proper that Ontario's payment should go to the Federal Government. Under the 1932 proposals \$67 million was agreed upon as the sum payable by Ontario. As the total estimated cost to the Federal Government for work in the International Rapids section was \$22 million, it would have actually come out of the International Rapids section \$45 million to the good. This sum could have been applied to the cost of works in Quebec to which the Federal Government was committed.

Under the agreement, Ontario meant, in effect, The Hydro-Electric Power Commission of Ontario. Ontario's only *uncontrollable* obligation was the \$67 million payable to the Federal Government. This was a binding commitment. An additional total expenditure of \$37 million would be made in due course for the construction of generating stations, but this was controllable, and would be made on whatever schedule best suited Ontario's needs. In other words, all of the \$37 million for a generating station could be deferred as long as St. Lawrence power was not needed by Ontario and, of course, it could be ex-

pended unit by unit to produce power as required. All this without imposing burden of any kind upon Ontario taxpayers.

On completion of this controllable and gradual outlay, eventually totalling $37 million, Ontario would finally secure 1,100,000 horsepower at a capital cost of $95 per horsepower.

To visualize the obligations assumed by the Federal Government, we must examine the project as a whole, including not only the International Rapids section which borders Ontario, but also the work in Quebec. The official figures for the 1932 proposals show the cost to the Federal Government of the work in Quebec as $83 million and for work in Ontario, $22 million; a total of $105 million. Deducting the $67 million payable by Ontario, the estimate of the Federal Government's out-of-pocket expense for the whole St. Lawrence river became $38 million.

However, it is well for us all to remember that all estimates are based upon unit costs for material, for labour, and for equipment. If, on account of direct or indirect inflation the actual unit costs should differ very materially from the estimated unit costs, it is highly probable that a corresponding variation would occur in the total cost of the project. But the increase or decrease in cost caused by such variation should be fractional only.

The Jackman Pamphlet

I must now refer, though with some measure of regret, to a pamphlet entitled "The St. Lawrence Project, published by W. T. Jackman, Professor of Transportation, University of Toronto, February, 1940". Thousands of copies of this pamphlet have been printed and circulated and excerpts have been extensively quoted throughout Canada and the United States. Many well-meaning people have been influenced by the use of the name "University of Toronto", and many interested parties have seized upon that name for its propaganda value, yet I have a letter from the University informing me that the pamphlet "is not published or approved by the University in any way".

Having regard to Mr. Jackman's university affiliations and the great numbers of his pamphlets that were printed at Fort Erie and broadcast all over the North American continent, it would be interesting to know whether he published it at his own expense as a personal contribution or whether it was sponsored by any person or organization and, if so, the name of such person or organization. Had this information been given, the pamphlet could not have been mistakenly presumed to be an official and hence an impartial publication of the University.

While I am sorry to criticize the work of a Canadian university professor, I feel compelled to deal with this pamphlet because of grossly misleading and erroneous statements which it contains and because of an unjustified reference to The Hydro-Electric Power Commission of Ontario.

From the viewpoint of capital cost, the more serious errors in Mr. Jackman's pamphlet relate to power from the International Rapids section. On page 6 of his pamphlet, Mr. Jackman says: "This would mean that in order

to get 1,100,000 horsepower of electric energy, the Province of Ontario, which would receive all this power, should have to bear the cost of its production, that is $670,000,000". Mr. Jackman makes it clear on page 4 that he is considering only the "International section" and not "the full development of power and navigation down to Montreal".

As I have already indicated, Canada's net out-of-pocket expense for actual work in the International Rapids section is $59 million. Under the 1932 proposals, Ontario's out-of-pocket expense for power is $104 million which includes a payment of $67 million to the Federal Government, a sum which is sufficient to pay for all of the Federal Government's work in the International Rapids section and leaves $45 million to be applied to work in Quebec. But under Mr. Jackman's assumption that no work would be done in Quebec, what figure, based upon official estimates, have we to compare with his $670 million? I think all we can say is that such a figure would lie somewhere between $59 and $104 million.

Fantastic as this figure of $670 million is, when compared with the official estimates, its origin is simple. It is largely the outcome of pyramiding error upon error. Let me give you a few examples.

First; Mr. Jackman assumes that half the cost of the work in the International Rapids section is chargeable to Canada. As I have already pointed out, Canada was to pay very much less than half the total cost of the work.

Second; Mr. Jackman includes in his estimate the cost of interest during construction. Although this is not usual in Government estimates, I have no quarrel with the inclusion of interest if correctly calculated. But in his calculation of interest Mr. Jackman has used an approximate method based on a much longer construction period than that clearly set out in the schedule included in the official report and he assumes a uniform rate of expenditure throughout. His interest calculations are $35 million on the high side.

Third; To the foregoing Mr. Jackman adds $100 million for Canada's share of work in or above lake Ontario, which does not appear in the official estimates, and he assumes that the cost of this work should be charged to power.

Is it reasonable to suppose that large sums of money would be spent for navigation in and above lake Ontario as well as in the International Rapids section while omitting work in Quebec that would make through traffic possible? If such navigation work were deemed to be advisable, why should it be charged to power in the International Rapids section?

Fourth; Mr. Jackman multiplies his swollen figures by 2½, because the official estimate, although prepared by a board of competent engineers, after exhaustive study and having before them unlimited data, was, in his opinion, not high enough. As plausible justification of this procedure, he cites the increase in cost of certain major engineering works, disregarding factors such as enlargment of the project during construction and neglecting all the many other undertakings on which the costs were consist-

ent with the estimated figures. It is my considered opinion that if this work were to be re-estimated on the basis of present-day unit costs, the figures would be lower rather than higher. Since the preparation of the estimates, great advances have been made both in methods and equipment employed on undertakings of this nature, which should result in reduced costs in carrying out this project (unless offset by rising unit prices due to some form of inflation, against which there is never any defence on any project large or small).

Aside from the question of the adequacy of the official estimates for navigation work, there is another absurdity due to the indiscriminate application by Mr. Jackman of his correction factor. Mr. Jackman has not only multiplied legitimate items of cost by 2½, but he has also multiplied his errors, for he has made large items, included in error, 2½ times larger than they were originally.

He has also multiplied by 2½, large and readily predictable items such as the cost of generating stations proper; by this I mean the buildings and apparatus, exclusive of the dam and main hydraulic works. It is well known that generating stations are almost invariably constructed at a cost that is in reasonable agreement with the estimates.

By these and other means Mr. Jackman contrives to "blow up" the official figures for the work in the International Rapids section to $670 million and he says that all this work should be charged to power. Mr. Jackman assumes that nothing whatever would be spent within the Province of Quebec to complete the navigation link to the sea, and, as I have indicated, the official figures for the work chargeable to power on this basis would lie somewhere between $59 and $104 million, depending upon what sum was paid by Ontario to the Federal Government. Bear in mind that his figures include huge amounts to be spent for navigation above the International Rapids section, specified by himself and not by the Board. To turn Mr. Jackman's own adjectives against him, truly his figures are "grossly perverted, absurd and grotesque".

General Comments

All National Bodies Have Approved

When evaluating the weight which should be given to the official estimates as compared with some of the biased propaganda, do not lose sight of the fact that over the years a great many national and international boards have been convened and reconvened to study the St. Lawrence navigation and power development and every one of those official national and international bodies has reported in favor of the project. An enormous amount of data has been accumulated, sifted and weighed. It is probably safe to say that no project has been more exhaustively and painstakingly studied by the most qualified persons available.

Remember, too, that while the works to be carried out in the International Rapids section are of a large order, they are not of unusual magnitude when compared with recent undertakings that have been conceived and launched while the St. Lawrence project remained under consideration.

Nor are the uncertainties of the St. Lawrence project greater than other large projects which have been successfully completed during the same period of time.

Is the Moment Opportune?

What interest, you may ask, has The Hydro-Electric Power Commission in the St. Lawrence project?

It is quite evident that this development cannot be classed as a war measure, for even if it were undertaken to-morrow, it would be six or seven years before it could become of use. Yet the project is persistently misrepresented as a war measure which, far from helping, would actually handicap war work. Since Canada's expenditure during the war would be small, this is untrue. As to the aftermath of the war, by entering into a treaty now, there is every reason to feel that the project will be of great social value as an aid toward the rehabilitation of returned soldiers. This is a factor of prime importance.

I want to make it quite clear that the Commission is not yet wholly dependent upon the early development of the St. Lawrence for its additional power supplies. There are substantial power resources on the Ottawa river which can probably be made available more quickly than the St. Lawrence, but they involve interprovincial agreements with the Province of Quebec and the purchase by the Commission of Quebec's share of the power available from any given site.

From the point of view of immediate supplies that might be required during the course of a protracted war there is one rather important advantage which would be secured through a St. Lawrence agreement. It opens the way to the use at Niagara or at DeCew falls of water that can now be diverted from the Long Lac and that could be diverted from the Ogoki within a period of about two years. The Ogoki water could also be used on the Nipigon. In addition, the St. Lawrence agreement would almost certainly make available additional water for power at Niagara, quite independently of these northern diversions. That water could be used immediately for the production of additional energy from the Commission's existing plants at Niagara by operating them more continuously and, when needed, it would make possible a 200,000 horsepower peak power development at DeCew falls or another base power development at Niagara falls.

Must Plan for the Future

What we must know, and must know soon, is whether or not the St. Lawrence is to go ahead at once. Our plans for the next five or six years will be very different in the one case from the other, and we must have a decision that will enable those plans to be laid within a very few months. This is the crux of the whole situation so far as I and my colleagues are concerned.

Negotiations at Ottawa and Washington

Now a word about the negotiations at Ottawa and Washington; my part in them might easily be misunderstood, yet it is very simple. It has been to furnish engineering information, to help explore possible engineering com-

promises essential to agreement, and to help reconcile divergent engineering and economic views. Any pressure from me has been for a decision as to whether or not to proceed: never for a particular decision, either affirmative or negative.

Action When it is Possible

Notwithstanding all this, there may be many people who would question the wisdom of inaugurating so great an undertaking as the St. Lawrence project at this time. That viewpoint is understandable, but there are circumstances under which action must be taken at the time when it is possible to take it.

Where there are four parties to any agreement and a fifth that must be considered, it may be difficult to find a time that is ideally suited to all. This project that involves Canada and the United States, New York State and the Province of Ontario as active participants, with Quebec as an interested one, has been fraught with all sorts of difficulty, political and otherwise. Where three of the four participants are ready, and where the fourth believes in the soundness of the project, surely the occasion may be said to be opportune. If it were not for the war we should scarcely hesitate; if we wait, other even more formidable obstacles may arise.

Expenditures Above and Below Montreal

I believe the St. Lawrence navigation and power project to be sound. I believe also that if an expenditure of approximately $38 million by Canada were needed to remove an obstruction in the way of 35 ft. navigation from Quebec to Montreal, it would be forthcoming overnight. Since 1925 at least $45 million have been spent on this channel in addition to $26 million previously expended. I believe that Canada need have no greater hesitation about making a $38 million expenditure to bring 27 ft. navigation from Montreal to lake Superior.

RESUME

As a last word let me again remind you of the amounts of money involved according to the official estimates under the 1932 proposals. The Federal Government would be obligated for navigation works in the International Rapids section to the extent of only $22 million of which little would be spent during the war. Navigation in Quebec would cost $83 million more, none of which would be spent during the war. Thus the total cost of work to be done by the Federal Government would be $105 million. From this sum $67 million contributed by Ontario in lieu of power advantages secured in the International section must be deducted. This leaves a net out-of-pocket cost to the taxpayers of Canada of $38 million.

In addition to the $67 million which The Hydro-Electric Power Commission would pay the Federal Government on behalf of Ontario, the Commission would expend approximately $37 million for its own generating stations, making a total of $104 million of which the $37 million would be expended unit by unit as and when power needs make it advantageous to do so. None of this money would be secured by taxation.

Again let me point out that all these figures neglect any possible effect of inflation.

With these figures firmly in your mind, I do not think you will be led far astray by those who search for means of confusing and distorting the issues involved in the St. Lawrence project rather than seeking to present the true facts and information in proper perspective so that Canadians, interested in the general advantages of Canada, may safely draw their own conclusions.

I have studied the St. Lawrence development project very closely over a period of twenty-five years. During all that time my work and my viewpoint have been closely identified with power requirements in Ontario. This may unconsciously handicap me in appraising the project in terms of the general interest of Canada. Be that as it may, though I am not an active advocate, yet I am satisfied that Canada would make no mistake in joining with the United States in the development of the St. Lawrence river for power and navigation.

Grounding Practice In Electric Systems

With Particular Reference To Protection From Shock

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THE primary aim in grounding electric power systems is to prevent damage to equipment and to protect workmen and the public against injury from shock. Its secondary function is to assist in system operation. These aims sometimes involve conflicting requirements, with the result that practices vary considerably depending on individual opinions and local conditions. There is probably no subject in the electrical field which has been productive of a greater variety of opinion and practice; while the general principles have been thoroughly understood for many years, it has not been possible to establish general rules not subject to exceptions, nor to apply principles without the exercise of judgment based upon experience.

A comprehensive review of practice is not possible within the bounds of a short discussion; consequently the scope of this paper will be limited largely to the status of grounding practice in Canada.

General

From the point of view of personal safety, current is of greater signifi-

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cance than voltage. In order to prevent fatalities from electric shock, it is necessary that the current through the human body does not exceed safe limits for a definite period of time. This current is fixed by the potential difference between the conducting parts with which two portions of the body may come in contact. Differences of potential may exist between parts of an electric circuit and metal objects in the vicinity or between metal objects and the ground, or between the circuit and the ground, and it is these values which constitute the lurking danger and are thus more important than the absolute potential of the circuit.

It is important to distinguish between two conditions which may produce a hazard. Differences of potential may exist between conductors insulated from one another, the values of which depend upon the charges on the conductors and the electrostatic capacity between them. Differences of potential may also exist between points of an electric system in which current is flowing. In this case the potential difference is determined from the current flow and the impedance between the points.

In order that an accident may occur, the following conditions must be satisfied:

(a) Exposed metal surfaces must be raised to a dangerous potential; this is usually caused by a failure in the insulation of the system or of equipment connected to it.

(b) A person must touch this exposed metal surface and at the same time make contact with the ground or with some other conducting surface at ground potential.

(c) The protective measures (fuses or circuit breakers) must have failed to function.

These conditions seldom occur simultaneously, and consequently the number of fatal accidents caused by electricity is extremely low having regard to the number of users of electricity.

In order to prevent fatal accidents, it is thus necessary that the conditions mentioned above do not occur simultaneously. To prevent this occurrence insulating materials on the system must be maintained in a good state of repair. They must be installed in such a manner that the chance of failure may be reduced to the minimum and the necessary protective measures must be taken to prevent the appearance of dangerous voltages on exposed metal surfaces. As a further safeguard means must be provided, should such voltages occur, for reducing the possibility that a current of dangerous magnitude can pass through the body of any person who may touch such an exposed surface.

A full discussion of the effect of electric shock on the human body would be impossible here for reasons of spatial economy alone, quite aside from the fact that it is an extremely hazardous field for a layman to enter. However, it may be of interest to quote some results obtained by investigators and to refer to values which have been incorporated in regulations. It will emphasize the great differences of opinion existing among authorities and illustrate the difficulties which face utilities in deciding upon practice, and

electrical authorities in framing regulations which will protect the public without working hardship by unduly increasing the cost of installation.

The passage of electric current through the human body causes paralysis of the higher nerve centres resulting in cessation of breathing, preventing normal reflex response and causing lack of tone of the blood vessels. The heart may be thrown into ventricular fibrillation, which is a disruption of normal heart action in which the heart appears to quiver rather than to beat.

Many investigations have been made using both animals and human beings as test media, and there is a large body of opinion to the effect that currents 10 to 20 milliamperes in magnitude may be endured for short intervals (less than one second) by normal human beings without dangerous consequences. Individual opinions, however, set this value as low as .3 to .4 milliamperes, while others estimate that the minimum current which can be perceived is approximately one milliampere. Other authorities have investigated the current required to cause ventricular fibrillation which they hold will always cause death, claiming that normal heart action cannot be restored if fibrillation occurs. The threshold of fibrillation is given by these authorities as about 100 milliamperes.

The time of occurrence of shock is an important factor; it appears to be accepted that if this occurs during a certain portion of the heart cycle (occupying about 20 per cent of the total period) much lower currents will be dangerous than if contact is made at another instant in the heart cycle.

The frequency of the shock current is also claimed to have an important bearing. One authority states that the threshold of fibrillation at 25 cycles is 25 per cent higher than at 60 cycles and at direct current five times as great as at 60 cycles. For shocks of short duration (.1 second or less) the effect of frequency is less marked.

It is important to note that the duration of the current, as well as its actual value, is an essential factor. This is recognized in the regulations of the National Electrical Safety Code respecting Electric Fences in which values of milliampere-seconds are incorporated. This Code limits the leakage current to 8 milliamperes in fence controllers of the continuous type. In Germany the maximum leakage current permitted is .35 milliamperes and in Switzerland .4 milliampere. The Canadian Electrical Code specification for a.c.-d.c. radio receivers sets a limit of 1.5 milliamperes for the leakage current from exposed metal parts to ground. (All these values apply to normal operating frequency.) The Verband Deutscher Elektrotechniker rules (German) state that condensers for protection against shock must not permit leakage greater than .4 milliampere when installed during factory construction and .8 milliampere if added subsequently.

The setting of values is sometimes complicated by conflicting requirements of regulations, for example, those governing radio interference may conceivably permit leakage cur-

rents beyond the values which some authorities regard as dangerous.

It is thus apparent that much research is still necessary in this field, and in the meantime practice and regulations should follow conservative lines and provide adequate factors of safety.

SYSTEM OF GROUNDING

The limits of the paper prescribed above necessitate a treatment particularly of distribution systems and circuits and of equipment on consumers' premises or on networks to which the public may be exposed. The primary purpose of grounding transmission systems is to protect equipment; the voltages are so high that they cannot be reduced to safe values by grounding, and structures and circuits are usually out of reach of the public so that the danger of accidental contact is small. Primary distribution systems (so-called) in many cases are scarcely distinguishable from transmission systems since voltages are frequently as high as 12,000. However, since these extend along public highways the danger to the public is greater than in transmission systems, and grounding practice is directed towards the protection both of persons and of equipment. Secondary distribution systems extend to customers' premises, and the primary object in grounding is here the protection of persons.

The trend in practice, at least in the United States and Canada, is towards grounded systems. While some transmission systems, and a few distribution systems, operate ungrounded the great majority employ star-connected transformers with the neutral grounded. The majority of these systems are 2300-4000 volt, 4-wire. In Ontario, two other voltages are used, namely, 4600-8000, 6900-12000 and all extensions in rural areas make use of one of these three voltage ranges.

A variation of the grounded neutral system is the so-called "Hood" system which had its birthplace in Toronto. In this the primary and secondary neutral points are connected to a common wire. This system is universally used in Ontario for extensions.

From the very nature of these networks grounding is essential. The present practice is to ground the neutral wire at all transformer and lightning arrester locations and at all services. There is considerable diversity in practice as far as the grounding of exposed metal parts is concerned and this will be discussed later in the paper.

In the grounding of low voltage distribution systems the practice is governed by safety code regulations in so far as customers' premises are concerned. The Canadian Electrical Code contains detailed rules on this subject and specifies the grounding of certain wires depending upon the type of network (single phase or polyphase) and the voltage of the system. In general, these rules require the grounding of the neutral conductor or the neutral point of the transformer secondary, or if no neutral is used the conductor which will establish the lowest maximum voltage to ground. The above applies to circuits having a maximum difference of potentials between conductors to be grounded and other por-

tions of the circuit, of 150 volts. The Code also recommends strongly that all system neutrals be solidly interconnected throughout the system (See Canadian Electrical Code, Fourth Edition, 1939, Rule 902 (a).) The neutrals of direct current, three-wire systems must also be grounded but this connection must be made at supply stations only and not on consumers' premises. The primary reason for this is that multiple grounds on direct current systems may aggravate troubles caused by electrolysis. Further, direct current systems are frequently run underground and in any case not exposed to public contact to the same extent as alternating current systems.

The Code also permits inspection authorities to waive ground requirements if it is impracticable to obtain the resistance to ground required by the Code.

Grounding Non-Current-Carrying Metal Parts

The grounding of non-current-carrying metal parts presents many problems in which local conditions are of great importance. Practice which may be satisfactory in some cases may be hazardous in others and each case should be studied with this in mind. The difficulties consist in harmonizing operating with safety requirements. The result has been a wide diversity in details of practice depending upon the relative weight attached to these two factors. It is not implied here that the personal safety factor is neglected in any case, but there is often a sharp difference of opinion as to the extent of the hazard involved. Two essential factors which must be considered are the magnitude of the potentials and currents and the duration of exposure.

Non-current-carrying metal parts may acquire potentials in several ways, each of which is responsible for exposures of different durations:

1. Induction between circuits may be responsible for voltages of varying magnitudes which endure as long as the circuits are "alive" and are thus continuous hazards.

2. Leakage through insulation, probably the most common cause.

3. Lightning either by indirect stroke or direct stroke.

4. Flashover from energized circuits or contact with energized wires.

In considering grounding problems the potential gradient, as mentioned above, is most important and if not duly considered serious hazards may be introduced by ground connections apparently satisfactory. In all types of ground connections, the voltage gradient is higher near the connection than at distant points and accidents have been caused by contact with ground electrodes in which the difference of potential has been beyond safe limits. Bonding of neighboring exposed non-current-carrying metal parts is often effective in reducing these potentials.

Stations

While this is beyond the scope of the paper, the value of station ground resistance is often of importance in reducing hazards in distant parts of the network. This, however, is usually taken care of adequately by utilities both for operating reasons and for the protection of workmen in stations.

Overhead Structures

All overhead lines and structures are potential sources of hazard as the general public is exposed to many portions of overhead systems. The difficulty is increased because the location of these lines is governed by load demand rather than the possibility of obtaining ground connections of low resistance.

Underground Structures

From the point of view of safety to workmen grounding should be an advantage because of the great opportunity of making good contact with ungrounded parts such as cable sheaths, etc. and the earth grounding is often supplemented by bonding where low resistances to ground are possible. On the other hand, it may, as mentioned above, increase electrolysis troubles.

Pole Hardware

There is considerable diversity of practice in the grounding of pole hardware. Some engineers favor the grounding of metal insulator pins, switch handles, transformer cases, braces, etc. to the neutral and to a common ground; others object to grounding certain hardware claiming that operating difficulties are introduced.

The bonding of metal parts on pole tops at transformer locations establishes a common potential for these parts but hazards to workmen may be introduced if adequate clearances are not maintained from live parts. The connection to ground is very important and reliance should not be placed on a single grounding conductor, at least two should extend down the pole and these should be guarded from mechanical injury so as to minimize the chance of a broken connection between the grounded metal and the earth.

Consumers' Premises

The primary object here is to protect persons from shock by limiting the voltage to ground to safe values. Grounding regulations play a governing role and a review of these is necessary to lend clarity to the discussion.

It should be stated that the two Codes in force in North America, namely, the National Electrical Code and the Canadian Electrical Code are not in complete agreement although in general principles they are in accord. The same may be said of Codes in Great Britain, the Continent, New Zealand and Australia, and a perusal of these indicates the necessity of considering local conditions rather than applying general principles universally.

The definition of grounded given in the Canadian Electrical Code is a very clear and concise statement of the requirements applicable in this case and is quoted below:

"Grounded: Connected effectually with the general mass of the earth through a grounding system having current-carrying capacity sufficient at all times, under the most severe conditions which are liable to arise in practice, to prevent any current in the grounding conductor from causing a harmful voltage to exist:

1. Between the grounded conductors and neighboring exposed conducting surfaces which are in good contact with the earth, or

2. Between the grounded conductors and neighboring surfaces of the earth itself."

The Canadian Electrical Code, in general, requires the grounding of all such parts operating at potentials greater than 150 volts to ground. Grounding is also required at any potential if conditions are "extraordinary." By this is meant where danger from mechanical injury, excessive moisture or extreme temperature is present in ordinary dwellings, offices, factories, etc. and where danger from corrosive, flammable or explosive atmospheres exists.

The Code also requires the grounding of the non-current-carrying metal parts of certain portable appliances, and in the last edition a list of about fifty is given which may be revised from time to time as necessitated by field experience or by new equipment appearing on the market. Portable appliances must be grounded by a flexible supply cord containing an extra grounding conductor. These requirements also include the exposed non-current-carrying metal parts of lamp holders, switches, plugs and receptacles installed in basements and in all damp places where danger from shock is likely to be present, also of non-portable cooking and heating appliances for all voltages.

The Code recognizes the impracticability of securing adequate grounding in certain cases and provides for alternatives, such as, insulation, isolation and guarding, and operation at low voltage.

For example, metal guards of extension cord lamps, which are used frequently under "extraordinary" conditions need not be grounded if they are thoroughly insulated from live parts. It is recommended that portable lamps and portable tools used in conductive locations in industrial establishments be supplied at low voltage (not higher than 32 volts) through a transformer having a separate secondary winding, in which case grounding is not required.

It is difficult to ground domestic washing machines, and the Code provides for safety by requiring that the motor be guarded, and mounted on supports which insulate it from the metal frame of the machine.

Isolation and guarding applies to equipment such as instruments, meters, relays, etc. in cases where the potential is between 150 and 750 volts, and the metal parts are made inaccessible to unauthorized persons by elevation or other means. Further, instruments operating at 750 volts and over are required to be isolated and guarded in addition to having non-current-carrying metal parts grounded.

It may thus be said that while the Canadian Electrical Code stipulates grounding as the usual method to be employed to secure personal safety, it recognizes practical difficulties which may arise and provides reasonable alternatives.

The Canadian Electrical Code also discusses in detail methods of grounding. Metal frames on stationary equipment are usually conveniently grounded through the wiring system, as the rigid or flexible conduit or the armor of armored cable affords a

metallic path to ground. Non-metallic-sheathed cable now may have a grounding wire incorporated in it. For portable equipment, flexible supply cords are now available having a grounding conductor forming part of the cord assembly. Polarized receptacles are necessary to meet this requirement and this will no doubt present a problem particularly in the older installations.

Difficulties in the domestic field also arise, caused by the multiplicity of portable appliances such as electric razors, massage equipment, electro-therapy devices, etc., continually appearing on the market, which may be used where moisture is present and where grounded metal parts may readily be touched. It has not been deemed practicable to require the grounding of such devices. The Code, however, recognizes the bathroom as a location offering conditions conducive to accidents and attempts to remove the hazards by prohibiting the installation of receptacles there.

This rule was inserted in the 1930 edition, and it may be of interest to note that since then three fatalities in bath tubs have been reported in Ontario as compared with eight during 11 years previous to 1930. While these figures may not be correlated with the change in the rule, it is believed they have some significance. Attempts have been made to remove this rule but electrical inspection authorities having continually in their minds the ingenuity displayed by the public in the misuse of electrical appliances, have steadfastly opposed these attempts.

Perhaps the only electrical appliance in extensive use outside of certain prisons, designed for the sole purpose of giving electric shocks, is the electric fence. Its use in the United States has reached such proportions that administrative bodies in certain States, the Underwriters' Laboratories and the Bureau of Standards have prepared specifications governing its construction and test. This device by its nature relies for its effectiveness on the leakage current to ground. It is thus somewhat similar to devices equipped with means for radio-interference suppression—the leakage current must be sufficient to accomplish its purpose, but must not exceed safe values. At first sight it would appear to be a prolific source of accident, but although it has been responsible for fatalities, sufficient operating data have perhaps not been obtained to justify positive statements as to the hazards involved. The device is not recognized in the Canadian Electrical Code although the type operated by a battery is accepted in some provinces.

(To be continued)

Lighting for Learning

By George G. Cousins, Supervising Lighting Engineer,
The Hydro-Electric Power Commission of Ontario

(Continued from March)

Artificial Lighting Requirements

The lighting of classrooms has received a great deal of scientific study that has resulted in the requirements being thoroughly established. It is therefore folly to install a system that does not conform to these known requirements. The two types of lighting that are usually used are the indirect and the semi-direct. The former is the preferred type as it is substantially free from glare, practically shadowless, and the most comfortable for the eyes. It must be used with a good reflecting ceiling, and its fixtures must be cleaned frequently. The semi-direct lighting is slightly lower in first cost and operating cost. At best, it is not entirely free from glare. Its chief claim for consideration is its lower initial cost, but when it is carefully planned the glare is kept at a tolerable level and it is fairly satisfactory. Groups 1 and 2 of Plate 2, Fig. 9, illustrate several styles of indirect lighting fixtures, and Group 4, the semi-direct styles. All of the fixtures of any one group produce substantially the same quality of lighting.

The selection of the correct fixture is of great importance as the success of the lighting depends upon it to a very great extent. It must have the proper light distributing characteristics, be highly efficient, and be capable of being easily cleaned. White glass enclosing units for semi-direct lighting should be of the proper size and shape, otherwise glare may be excessive and the light not properly distributed. Much engineering skill has been put into the design of good lighting equipment, and a few dollars saved on the first cost may represent many years' loss through inefficiency in lighting. The appearance or shape of a lighting unit is not a reliable indication of its suitability for any requirement, particularly to the layman. The only method of determining the lighting characteristics of a fixture is by a laboratory test. The only sound method of making a correct selection is to follow the advice of a competent lighting engineer.

The normal-sized classroom requires six lighting fixtures for desk lighting, less than this will result in unequal distribution of lighting. The spacing should not exceed 10 feet and the height will depend upon the characteristics of the unit.

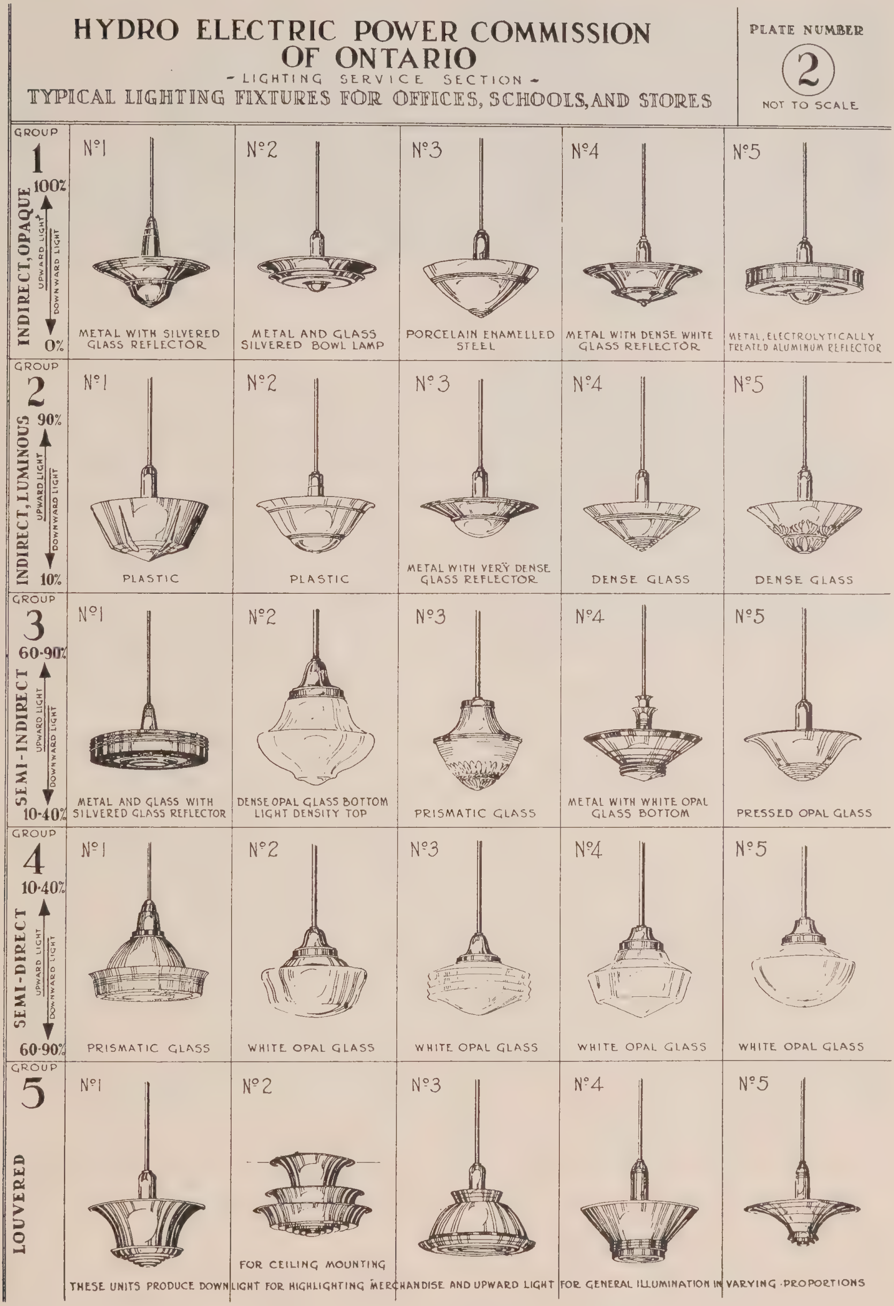

HYDRO ELECTRIC POWER COMMISSION OF ONTARIO
- LIGHTING SERVICE SECTION -
TYPICAL LIGHTING FIXTURES FOR OFFICES, SCHOOLS, AND STORES
PLATE NUMBER
2
NOT TO SCALE
GROUP 1
INDIRECT, OPAQUE
100%
UPWARD LIGHT
DOWNWARD LIGHT
0%
N°1
METAL WITH SILVERED GLASS REFLECTOR
N°2
METAL AND GLASS SILVERED BOWL LAMP
N°3
PORCELAIN ENAMELLED STEEL
N°4
METAL WITH DENSE WHITE GLASS REFLECTOR
N°5
METAL, ELECTROLYTICALLY TREATED ALUMINUM REFLECTOR
GROUP 2
INDIRECT, LUMINOUS
90%
UPWARD LIGHT
DOWNWARD LIGHT
10%
N°1
PLASTIC
N°2
PLASTIC
N°3
METAL WITH VERY DENSE GLASS REFLECTOR
N°4
DENSE GLASS
N°5
DENSE GLASS
GROUP 3
SEMI-INDIRECT
60-90%
UPWARD LIGHT
DOWNWARD LIGHT
10-40%
N°1
METAL AND GLASS WITH SILVERED GLASS REFLECTOR
N°2
DENSE OPAL GLASS BOTTOM LIGHT DENSITY TOP
N°3
PRISMATIC GLASS
N°4
METAL WITH WHITE OPAL GLASS BOTTOM
N°5
PRESSED OPAL GLASS
GROUP 4
SEMI-DIRECT
10-40%
UPWARD LIGHT
DOWNWARD LIGHT
60-90%
N°1
PRISMATIC GLASS
N°2
WHITE OPAL GLASS
N°3
WHITE OPAL GLASS
N°4
WHITE OPAL GLASS
N°5
WHITE OPAL GLASS
GROUP 5
LOUVERED
N°1
N°2
FOR CEILING MOUNTING
N°3
N°4
N°5
THESE UNITS PRODUCE DOWNLIGHT FOR HIGHLIGHTING MERCHANDISE AND UPWARD LIGHT FOR GENERAL ILLUMINATION IN VARYING PROPORTIONS

Fig. 9

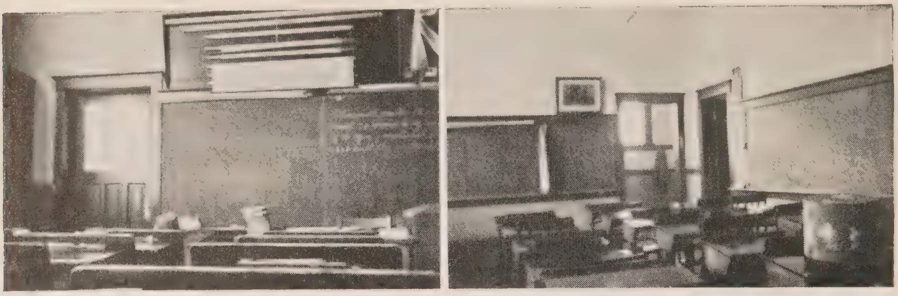


Fig. 10—Windows and doors in direct line of vision to the blackboard cause objectionable glare that interferes with vision.

Glare

Glare appears in many forms. Some forms cause discomfort, some annoyance, and some are not recognized but affect the individual in the form of eye fatigue. The most common effect of glare is to reduce visibility. Blackboard glare has been mentioned. Windows beyond the blackboard, as shown on Figs. 6 and 10, may not produce immediate discomfort but will produce eye fatigue. The most vicious forms are exposed unshielded lamps and bright spots on lighting units. There is no excuse for the first, and the second can easily be avoided by proper lighting units.

The presence of glare reduces the effectiveness of the illumination. For instance, a 100-watt lamp at different angles from the line of vision produces the equivalent of waste of illumination, as follows:

at 5° from line of vision	85%	of light wasted.
10° " " " "	73%	" " "
20° " " " "	60%	" " "
40° " " " "	48%	" " "

(Data from Dr. M. Luckiesh)

The elimination of glare is as necessary as the provision of adequate intensity.

Automatic Control

The best lighting system will yield no benefits unless it is used. It is unfortunate in one sense that eyes adapt themselves so well to changing conditions. Because of this, daylight may drop to a value far below that at which artificial lighting should be turned on without one being conscious of it. It is only when the strain begins to tell that one realizes that the lighting is exceedingly low. Added to this is the fact that teachers may not be engaged in severe visual tasks and may fail to notice the need for artificial lighting. It is thus obvious that manual operation is not likely to be reliable at all times. In one school where a record was made in adjacent rooms it was found that an automatic control set to turn the lights on when daylight dropped to 12 foot-candles on desks farthest from the windows operated the lights for about three times as many hours

per day as the manual control in the next room.

The operation of automatic control depends upon local conditions. Where there is a really good sky exposure, with large windows, the control may operate the lights farthest from the windows when the daylight falls to 15 foot-candles. Under less favorable conditions it would be better to leave the inner row of each room on the one side of the school on all day and operate the outer row by automatic control. One automatic control is usually sufficient for all of the rooms on one side of a school, as they are all exposed to the same daylight conditions.

If manual control is to be relied upon the teachers should be instructed in the use of the artificial lighting system and instructed to use it.

WINDOW SHADES

Window shades are not actually part of a lighting system, but they play a very important part in a seeing system. Their primary purpose is to prevent glare from direct sunlight. They should be used for this and for nothing else. Practically all the daylight that reaches the desks in the far side of the room comes through the upper halves of the windows, and when the upper halves are shaded it reduces the lighting on the farther desks to from 1/4 to 1/10 of its former low value, thus further penalizing the pupils that are already heavily handicapped.

There are several types of window shades, the most commonly used of which are roller and venetian blinds. The latter are more flexible in use and may possess some slight light distributing characteristics. Roller blinds commonly used are of heavy opaque material that completely absorbs the light that they intercept. White translucent material is much better as it transmits and diffuses some of the light instead of absorbing all of it. Some roller blinds are mounted so that they may cover part of the window and the whole blind, roller and all, be moved up or down. This is an advantage as the sun enters at different angles of elevation at different times of the year and this can be compensated

Fig. 11—Window blinds on the shady side of schools covering one-half or more of the most valuable portion of the window area — an inexcusable practice.

for. Another good method is to mount two roller blinds midway between the top and bottom of the window, the upper one to be unrolled toward the top, and the lower one toward the bottom as required to suit conditions.

The correct use of window shades is very important, and teachers should be instructed regarding the correct method. There is no justification whatever for covering the upper parts of windows on cloudy days or on the shady side of the buildings, see Fig. 11. This might also apply to fancy window trimmings, except for special occasions. The handicapped children farthest from the windows are the ones that suffer. A large percentage of the roller blinds in classrooms are in bad mechanical condition, and this may be a contributing cause of the lack of proper use. They are useful when properly used, but decidedly detrimental if not.

Wiring

Inadequate wiring is the weak link in the chain of facilities for the improvement of seeing through lighting. The Electrical Code is based only upon protection from fire hazard; in other words, it prohibits wire being used that may get hot enough, because of inadequate capacity, to set fire to a building. A wiring system may comply with the Code requirements and still be inadequate for good lighting because of the loss of power in the wire itself.

Our wiring recommendations specify a minimum of No. 12 B & S gauge wire for branch circuits, although No. 14 gauge will often satisfy the requirements of the Code. Four hundred hours represents about 35 per cent of the annual school hours (day classes). For every 1500 watts burned for 400 hours No. 14 wire may waste as much as $15.00 worth of the power that flows through the meter at 2c per kw-hr. that produces heat in the wiring instead of light in the lamps. The adequate system will cost about 1/3 more than the skimped system, but the former will contain heavy-duty switches which will last as long as the wiring and other details in proportion, while the skimped system will be skimped to the irreducible minimum. The switches will require replacement frequently, the wattage capacity will be the minimum, and the circuits will be as few as possible, with the result that all of the lamps in one room would be burning at one time whether they are all needed or not. Under average conditions the extra cost for an adequate system would be recovered in a year or two.

Windows

There should be no windows or openings beyond the blackboard through which the outdoors may be seen, as this is a very serious source of glare. Where such openings exist they should be permanently painted or blocked so that no light can shine through them. Figs. 5 and 9 show some examples of this form of glare. The enormous contrast between the brightness of the window opening and the dark blackboard renders the writing on the blackboard very difficult to see and the eyes suffer in the attempt.

Windows at the right side of a room are of very doubtful value. In addition to causing cross-lighting with annoying shadows they also result in blackboard glare from both sides of the room, thus handicapping twice as many pupils.

Rear windows, unless the upper halves are shaded, usually spread glare over the entire blackboard, and if they are shaded the light that enters is practically useless. There is very little to be gained by rear windows and much to be gained by eliminating them.

Conclusions

The school with all its organization and facilities is built upon the needs of children, for their preparation for the serious phases of life; and since the success of all this expenditure of time, money, and human energy depends, preponderantly, upon the effective use of the sense of sight as a channel through which impressions flow that are converted into knowledge, it seems logical that every consideration would be given to those factors that affect the ability of children to see clearly, easily, and without avoidable strain. On the contrary, there is a more or less general readiness to grasp at any excuse for not meeting this issue fairly, apparently because lighting is looked upon as an overhead expense instead of the most valuable means of reducing retardation. It has been established beyond question that good lighting decreases the number of repeaters to about one-third of the number that fail in poorly lighted rooms. Furthermore, progress under good lighting is more rapid than under poor lighting. Every item of knowledge gained is a stone in the foundation of an education. Tomorrow's lessons are built upon the knowledge gained today. If, because of inability to see clearly, items of knowledge are missed, the whole structure becomes weak.

The cost of prevailing lighting per pupil per year varies according to local conditions and equipment, but records that are available show it is considerably less than $1.00. The total cost of education per pupil per year will probably be between $100.00 and $150.00 for urban and high schools, and $50.00 to $90.00 for rural schools. Poor lighting may cost approximately $1.00 per pupil per year. Good lighting in accordance with the Department of Education requirements may be had for about $3.00 per pupil per year. If good lighting will result in only one pupil passing who would otherwise have been a repeater, the money will have been profitably spent.

Records have shown that many of the eye defects develop in childhood. These require spectacles for correction, although many children who should wear glasses do not do so. Fifteen dollars for examination and glasses is a fair average value. Thus, one pair of glasses would pay for good lighting for the child for five years. Where records have been kept of the results of good lighting it has been found that the better lighting has more than paid for itself.

So far only the monetary aspects have been presented. But what about the humanitarian aspect? Glasses are obviously a handicap in the

Fig. 12—Luminous indirect lighting (fixtures from group 2, plate 2, Fig. 9). Prismatic blackboard lighting. (Photograph from Northern Electric Company).

broad sense, as they restrict the play activities of a child, and in later life they become a positive nuisance, although necessary, as well as affect the career of the then adult. Eye fatigue has a very definite effect upon an individual's health which in turn adversely affects his or her capacity for accomplishment. It is not inferred that all eye defects are the result of poor lighting, but the records of eye examinations in progressively higher grades is certainly sufficient to point to faulty lighting as a major contributing cause.

Most of the difficulties of seeing are directly related to lighting, and since little or nothing can be done to improve the utilization of daylight the only alternative is the use of artificial lighting which can be controlled to suit any practical requirement.

It is strange but true that the recommendations of men whose life's work is lighting, and who have had many years of experience in studying and planning lighting for schools, are ignored by many School Boards in favor of the off-hand statements of wiremen who have given the subject no direct thought. This has resulted in a great deal of dissatisfaction and loss of both money and

Fig. 13—Semi-direct lighting (fixtures from group 4, plate 2, Fig. 9). Elliptical angle blackboard reflectors.

time in having the obvious defects corrected. It costs nothing to have lighting properly planned, and it is false economy to stint on the initial cost when many generations of children will have to endure the penalties of poor lighting.

Many factors influence the seeing conditions in classrooms. A relatively small intensity of glare may nullify the merits of the best lighting system. Each factor should receive careful consideration, as only by making full use of every aid to vision will the most beneficial results be obtained.

In schools without adequate lighting equality of opportunity amongst the pupils in various parts of a room is utterly impossible. A good lighting system will render the teacher and pupils independent of the uncertainties of daylight and provide good seeing conditions for all.

Convention Question Box

DURING the O.M.E.A. and A.M.E.U. convention at Toronto on February 7th and 8th, a part of one session was given over to answering certain questions that had been circulated previously. Space does not permit giving the verbatim discussion on the questions, so instead we are outlining below the points brought out. Their publication does not imply the concurrence of *The Bulletin* in all the opinions expressed.—Editor.

Question:—

1. What is the effect of unbalanced load on secondary voltage of two transformers with secondaries in series serving a 3-wire 115-230 volt lighting load?

Answer:—

Where two transformers are connected in series the effect of unbalanced load is simply a reduction in voltage on that side of the neutral having the greater load, due to the load itself, and not, as in the case of the 3-wire transformer, when the opposite side is affected also. The effect is less where there are two transformers in series than where a transformer is connected 3-wire.

With two transformers in series the inherent reactance will be changed slightly from that of one transformer due to extra length of wire joining the transformers together. This plus the small difference in voltage regulation between small and large transformers will cause a slight difference in the unbalance where two transformers are used or only one; otherwise the effect would be the same.

Question:—

2. To what extent are municipalities making use of the socket type outdoor meter, and what are the observations of those who have made use of them?

Answer:—

Some of the municipalities have been installing socket type, outdoor meters for periods extending over three years. They report the operation of such meters entirely satisfactory, with no failures. The placing of the meter outdoors makes it more accessible, especially where it was formerly in the attic. The outside location also removes the necessity of the meter reader making a second visit on account of finding no one at home on his regular call. Outdoor meters are supplied with standard bases generally, which permits the interchange of meters of different manufacture. Some municipalities supply the bases to the wiring contractors free, while others make a charge covering a part of their cost. The service wiring inside the house is usually run into the basement to permit the installation of fuses there and also flat-rate water heaters.

Question:—

3. Is it good practice to connect a three phase transformer bank feeding both single phase and three phase load, star to star; if not, why not?

Answer:—

Generally speaking, it is not good practice to connect three-phase transformer banks star to star, whether for lighting load, or power load, or both. That is because of the third harmonic current which circulates in the winding, reducing the capacity of the transformers, in the first place, and also creating a circulating current in the system, which sometimes causes telephone interference. This is particularly true where there are large transformers and long connecting lines between them.

In some cases where the transformer installation is small, supplying power and lighting at 120-208 volts it would be good practice since the third harmonic current would be very small compared with the line current. It is important that only modern transformers with low magnetizing current be used in such installations.

Question:—

4. Do you think this Association would be justified in setting up an arrangement similar to the Water Works Information Exchange?

Answer:—

The Waterworks Association draws its members from the various waterworks systems, each of which is a complete unit within itself. By the Waterworks Exchange the members have established a central agency where all kinds of data regarding the practices of the members are collected and given out. The Hydro utilities, however, although independent units, have a central agency in The Hydro-Electric Power Commission of Ontario which goes to a great deal of trouble compiling exhaustive information relative to every municipal utility. Also the Commission's telephone system gives a means of direct communication with the Commission and among the utilities, so that answers may be obtained very quickly. On account of the difference in the organization of the Waterworks Association and of the Hydro, where the Waterworks Exchange is very necessary, there is no advantage in establishing a similar exchange in the Hydro set-up.

Question:—

5. What regulation has your commission with regard to the placing of radio aerial wires over electric services from the pole to the building? Is there a need for any regulation?

Answer:—

The discussion showed that there have been serious accidents from stringing aerial wires over electric distribution lines, and that in some municipalities local regulations have been passed forbidding the practice. Where permission is asked to attach aerials to distribution poles it should be refused, and while those who know what they are doing will keep their aerials as far away from a.c. lines as possible, the line superintendent could have dangerous conditions that he may find removed. Probably it is a matter of education beginning at the public school.

Question:—

6. "Lamp Efficiency, versus Customer Satisfaction",—In spite of all explanations, the public appears to be more concerned with the life of

lamps than the efficiency, and the public questions the quality of the manufacturers' product and the Hydro supplied.

Answer:—

Possibly there have been complaints about the life of lamps, and some manufacturers in an effort to meet competition with long life lamps may have been selling higher voltage lamps thus sacrificing efficiency.

The rated life of Hydro lamps is well known throughout the whole system and there has been no departure from the standard of quality that has been followed from the beginning. From time to time there have been improvements in efficiency without the sacrifice of life. There has been no lowering of the quality of Hydro lamps. Hydro lamp sales records do not indicate any lack of public approval. Attention is directed to the fact that proper voltage is necessary for the most satisfactory operation of lamps. An increase of 5 per cent over the rated voltage of the lamps will reduce the life to approximately one-half of its rated life.

Question:—

7. Should the conditions of employment of operating and construction staffs of the various municipal commissions be standardized for the different sizes and types of municipal systems in the different sections of the province, especially in regard to qualification of personnel, hours of work, sick leave, vacations with pay, etc.?

Answer:—

The reply to this question was "No". To attempt to do so would usurp the powers of the local commissions who should be the best judges of what is necessary to be done in their municipalities. That any attempt to do this would meet with many difficulties and cause disputes, confusion and no end of trouble for all parties concerned. That the majority of the commissions want to be fair in their dealings with their employees.

Question:—

8. What experience have members had with the use of the recent self-protecting transformer? Is it safe practice to forego the use of door type cut-outs on any pole-type transformer installation?

Answer:—

Two installations, each of three 25 kv-a. C.S.P. transformers in banks were made in London and their operation studied. The idea was to find out if more work could be got out of a transformer. Taking into account load factors, air temperatures and the human factor, the transformers might not be loaded sufficiently and the use of clip-on ammeter, demand meters, or graphic meters does not supply the whole answer. Possibly the C.S.P. transformer would get nearer to the truth and the little red light might do a real job, also that the secondary breaker might prove useful when getting information on the operation of banked transformers. The first three 25 kv-a. transformers replace a 37½ kv-a. carrying 52 kv-a. and a 30 carrying 24 kv-a. Two were erected first but when one showed a red light the third was added. They performed very satisfactorily all winter but

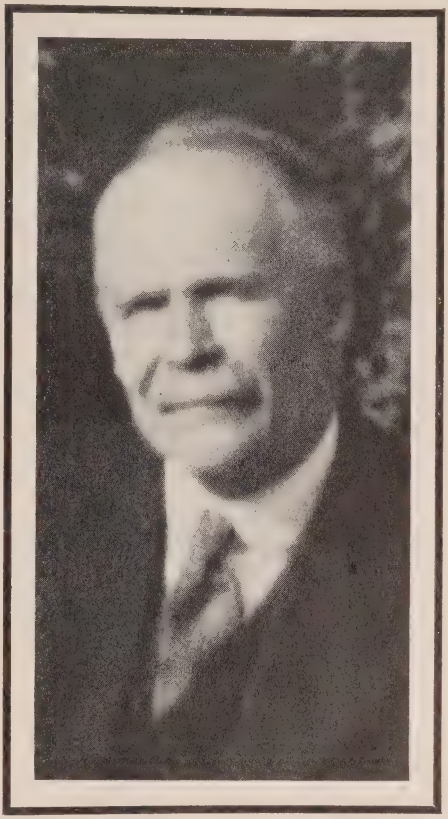
there is 75 kv-a. capacity where there was 67 before. The other bank of three 25 kv-a. transformers is carrying 43, 51 and 37 kv-a. on each respective unit as shown on a demand meter and checked on graphic meters. The graphic meters showed a daily load factor of about 45 per cent. None of the second bank of three transformers has shown the red light. There is nothing to report regarding lightning trouble. Cutouts with solid blades are used on the primary side which serve as disconnects.

The delegates were reminded of a paper read at the 1939 Summer Convention describing the C.S.P. transformer and were urged to co-operate with the manufacturers in giving newly designed equipment a fair trial to see if it will do everything it is supposed to do.

It would seem, from an operating viewpoint that we should hesitate before eliminating cutouts when installing the new style of transformer if for no other reason than switching. The suggested practice of requiring linemen to climb through wires carrying varying voltages in order to disconnect the drops to the transformer does not conform with recognized rules for safe practice. The saving that might be made through the elimination of the cutouts is only negligible, especially from the standpoint of accident prevention.

V.B.Coleman, Port Hope

Vincent Booth Coleman, manager and secretary of the Port Hope Hydro-Electric Commission, died on Thursday, April 4th, in his 71st year. A week previous to this he was admitted to the Port Hope hospital suffering from pneumonia. He was believed to be on his way to recovery earlier in the week, but later passed away.



V. B. Coleman.

Mr. Coleman was born in Seymour township, Northumberland county, and moved to Port Hope with his parents at an early age. His interest in electricity began when he was a boy, when the telephone intrigued him. In 1885 an open arc electric lighting system supplied from a steam plant and capable of serving

twenty lights was installed, and he became manager of this plant. Later the plant was moved and driven by water power. About this time he entered the employ of a Montreal company, but returned to Port Hope in less than a year and accepted a position with the Port Hope Electric Light and Power Company, which purchased water rights north of the town. Here, a 750-light Slattery alternating system, one of the first in Canada, was installed in addition to the arc machines. When this plant was taken over by the Electric Power Company in 1910, Mr. Coleman remained with the successors, where he later became manager. He has served in this capacity until his death, the Port Hope System having passed into the ownership of the Province of Ontario in 1916 and was operated by The Hydro-Electric Power Commission of Ontario until 1930, when it was purchased by the town. At this time he also became secretary of the local commission.

He was widely known for his kindly character and a wide host of friends and business acquaintances mourn his passing. Mr. Coleman is survived by his widow, one daughter and two sons.

R. A. Coleman, Port Hope Manager

On the death of his father V. B. Coleman, Robert A. Coleman succeeded to the position of manager and secretary of the Port Hope Hydro-Electric System. The appointment was made at a special meeting of the local Commission on Monday, April 8th, and is quite popular locally.

Graduating from Port Hope High School, Bob accepted a position with the local Hydro as meter man in July, 1926. Since that time he has remained constantly with the Port Hope system and under the guidance of his father, and by industrious studying in the electrical field has become familiar with all the phases of the system.

The Bulletin joins with his many friends in extending congratulations on his appointment.

THE BULLETIN

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Power Output in 1939

THE twenty-eighth annual survey of 100,000,000 kilowatt-hour systems in North America by *The Electrical World* includes operating data for 184 electrical light and power companies. Of those systems there are 43 that exceed one thousand million kilowatt-hours. On the basis of kilowatt-hour output The Hydro-Electric Power Commission of Ontario tops the list with a total output for the year, including purchased energy of 8,673,283,000 kilowatt-hours. Next in order is the Niagara Hudson System with 7,618,593,000 kilowatt-hours, followed by the Commonwealth Edison Company and subsidiaries and The Consolidated Edison Company of New York, Inc., with 7,561,618,000 and 7,376,854,000 kilowatt-hours respectively. Fifth in this order is the Shawinigan Water and Power Company and subsidiaries with 5,923,888,000 kilowatt-hours.

Taken in the order of system peak loads, including purchased energy, The Hydro-Electric Power Commission of Ontario comes second with a total load of 1,564,200 kilowatts taken on a 15-minute basis. The greatest peak load was that of The Consolidated Edison Company of New York, Inc., with a 60-minute demand of 1,660,000 kilowatts, while the third and fourth were the Commonwealth Edison Company and subsidiaries and the Niagara Hudson System with 1,535,000 kilowatts and 1,316,000 kilowatts respectively over 60 minutes.

The generator rating of the Commission of 1,160,000 kilowatts is fourth in magnitude, being exceeded by The Consolidated Edison Company of New York, Inc., with 2,566,300 kilowatts, the Commonwealth Edison Company and subsidiaries with 2,005,765 kilowatts and the Niagara Hudson System with 1,576,638 kilowatts. In hydraulic generation, however, the Commission is first with 1,140,000 kilowatts distributed over 45 plants. The System having the second largest hydraulic installation is the Niagara Hudson System with 979,788 kilowatts in 90 plants. Some of the other systems showing large hydraulic in-

CONTENTS

Vol. XXVII No. 5
May, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

stallations are the Pacific Gas and Electric Company with 876,794 kilowatts in 49 plants, The Bureau of Reclamation (Boulder Dam) with 704,800 kilowatts in one plant, The Shawinigan Water and Power Company and subsidiaries with 701,372 kilowatts in 18 plants, The Southern California Edison Company, Limited, with 656,920 kilowatts in 24 plants, Tennessee Valley Authority with 610,709 kilowatts in 19 plants, The Montreal Light, Heat and Power Consolidated and subsidiaries with 548,720 kilowatts in five plants and The Gatineau Power Company with 534,608 kilowatts in 17 plants.

Commenting editorially on this survey, the *Electric World* states that in its first survey, covering 1912, it included five companies, their peaks ranging from 42,500 kilowatts to 233,000 kilowatts and that this year the largest single peak is six times as large as the largest in the first survey, and the output ten times as large. At that time The Hydro-Electric Power Commission was only completing its second year of operation, its peak reaching to about 30,000 kilowatts. During thirty years of operation the Commission's load has grown from zero to one of the largest on the North American continent.

Investigation of Artificial Ground Terminals

By the Grounding Committee, H.E.P.C. of Ontario

DURING the period from July 1932 to April 1934 an extensive program of investigation of artificial ground terminals was carried out by the Distribution Section of the Electrical Engineering Department of The Hydro-Electric Power Commission of Ontario under the authority of a Committee on Grounding.

OBJECT OF INVESTIGATION

The idea of establishing ground test stations originated early in 1932, with the object in mind of securing information regarding the all-season characteristics of various types of terminals in the different classes of soils which are prevalent in Ontario.

Some information of this nature was available for other localities, viz. Winnipeg and Washington, but it was not considered to be properly applicable to the particular conditions met with in Ontario.

Specifically the following information was desired:

(a) What terminal, having the best practical all-season characteristics, should be used as standard throughout Ontario in districts where extensive water pipe systems were not available.

(b) The extent of seasonal variation of resistance, because of discrepancies in different reports regarding the same terminals.

(c) Definite and reliable observations concerning the effect of varying depths of frost penetration on the various types of ground terminals.

(d) The effect of precipitation on artificial ground terminals was known to be important, but complete and reliable data were desired.

(e) Reliable data on the behavior of shallow terminals in typical Ontario soils—also the relative effectiveness of strip and mat terminals.

(f) Additional information on soil treatment.

With the above mentioned objects in view, observations were made of ground resistance values with variables of season, soil, type of terminal, soil treatment, frost penetration, precipitation, and temperature.

TEST STATIONS

There are innumerable variations in soil conditions in Ontario which may, for practical purposes, be divided into general classes, as follows:

1. Clay.
2. Sand.
3. Gravel.
4. Rock.

Loam was not listed as a separate classification because it usually occurs only as top soil and is in general absorbed in the classes listed; e.g. clay loam, sandy loam, etc.

The designation of the fourth class,

viz rock, is used for localities having bed rock within a few feet of the surface, with an overburden of soil. This was known to be a particularly poor condition for grounding and it was hoped to find the answer by the use of shallow terminals.

Two test stations, or groups of terminals, were established in each type of soil, making eight stations in all. This was to reduce the chance of error which might occur if deductions were based on single experiments.

In order to be accessible all year round locations were sought along paved roads near Toronto. After careful study the clay, sand and gravel were located along the Lansing-Rouge Hills highway, while a rock condition was found on the flats of the Humber river just west of the city limits between Bloor and Dundas streets.

Work was commenced on the installation of terminals on July 11th, 1932 and completed on July 26th, 1932.

For future reference the system of numbering the stations is listed below.

Terminals

The selection of terminals to be tested included samples of nearly all types considered to be of practical value for our purposes, with the idea of adding to these any terminals that might be discovered or developed at a later date.

The first nine terminals in each station were identical, and are listed below with the terminal number allotted to each.

1. 6 in. by 6 in. wire mesh 20 ft. by 3 ft.—10 in. deep; or 6 in. by 6 in. wire mesh 10 ft. by 3 ft.—24 in. deep.

Note—Stations, 1, 2, 3 and 4, had the 20 ft. mat. Stations 1A, 2A, 3A and 4A had the 10 ft. mat.

2. 15 ft. tinned copper strip 1 by 1/16 in.—24 in. deep.

3. 15 ft. tinned copper strip 1 by 1/16 in.—24 in. deep.

4. 15 ft. tinned copper strip 1 by 1/16 in.—24 in. deep.

2 plus 3 plus 4 = 45 ft. copper strip 1 by 1/16 in.—24 in. deep.

5. 6 ft. by 3/4 in. steel rod.

Station Number	Soil	Location
1	Stoney black loam Rock at 3 to 5 ft.	Humber blvd.—station nearest Bloor street
1A	Clay loam Rock at 6 ft.	Humber blvd.—station nearest Dundas street
2	Clay	Scarboro twp. con. II, lot 34
2A	Clay	Scarboro twp. con. III, lot 34
3	Gravel	Scarboro twp. con. II, lot 8
3A	Gravel	Scarboro twp. con. III, lot 8
4	Sand	Scarboro twp. con. II, lot 9
4A	Sand	Scarboro twp. con. II, lot 8

The geographic locations of six of the stations are shown in Fig. 1.

6. 8 ft. by 3/4 in. steel rod.

7. 10 ft. by 3/4 in. steel rod.

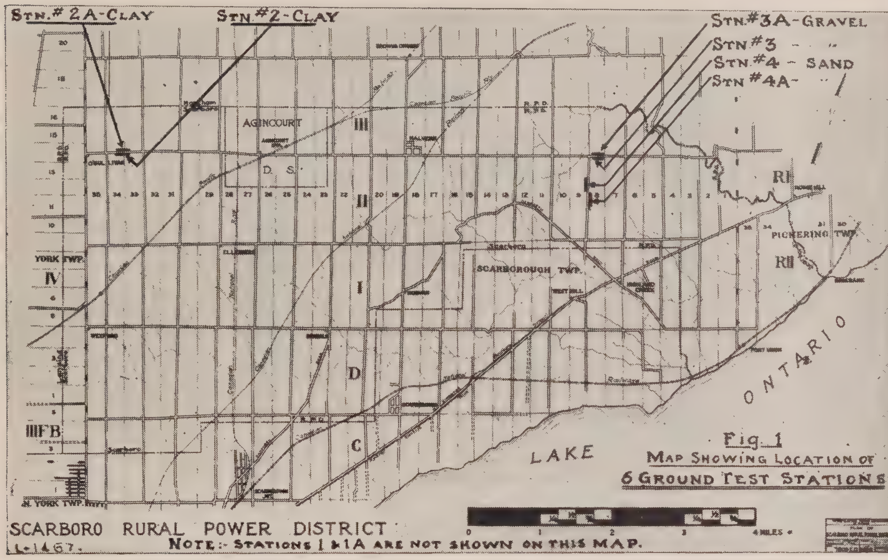


Fig. 1
MAP SHOWING LOCATION OF 6 GROUND TEST STATIONS

NOTE:- STATIONS 1 & 1A ARE NOT SHOWN ON THIS MAP.

8. 10 ft. by ¾ in. steel rod—salt treated—basin type.

This type of treatment consisted of digging a conical excavation around the top of the rod, 2½ ft. deep and 2½ ft. across the top, and placing 90 lb. of common salt in this hole. See Fig. 2.

9. 10 ft. by ¾ in. steel rod—salt treated—tile type. This treatment is similar to the basin type except that an 8 in. sewer tile, 2 ft. long, is placed around the top of the rod to act as a reservoir for the salt. The capacity of the tile is about 50 lb. of salt.

In addition to the above, other terminals were installed as follows:—

An 8 ft. by 1 in. perforated pipe—salt treated with NaCl solution and later with 2 lb. NaCl crystals. All treatment was applied inside the pipe on the theory that the brine would seep out and impregnate the soil in immediate contact with the pipe. These were installed at all stations on Oct. 28, 1932.

A 6 ft. by ⅝ in. perforated copper tube was installed at each station except No. 1 and treated with either NaCl solution or $CuSO_4$ solution, poured down the tube.

A T-shaped galvanized steel rod was installed at four stations on Aug. 19, 1932, 6 ft. long at station No. 1A and 10 ft. long at stations 2, 3A, and 4A.

A "spear head" type of terminal was installed at stations 2, 2A, 3, and 4. The spear head is of cast iron, about 6 in. long, and shaped like an auger point, with copper lead wire attached. These were installed to a depth of 5½ ft. by means of a special handle for twisting them in.

A star-shaped solid copper rod, ¾ in. maximum diameter was installed at station 2A on Oct. 28, 1932.

Deep Terminals — From January 20th to February 3rd, 1932, seven deep terminals were installed by the use of an electric hammer. These rods were of steel in 5 ft. sections in three sizes—

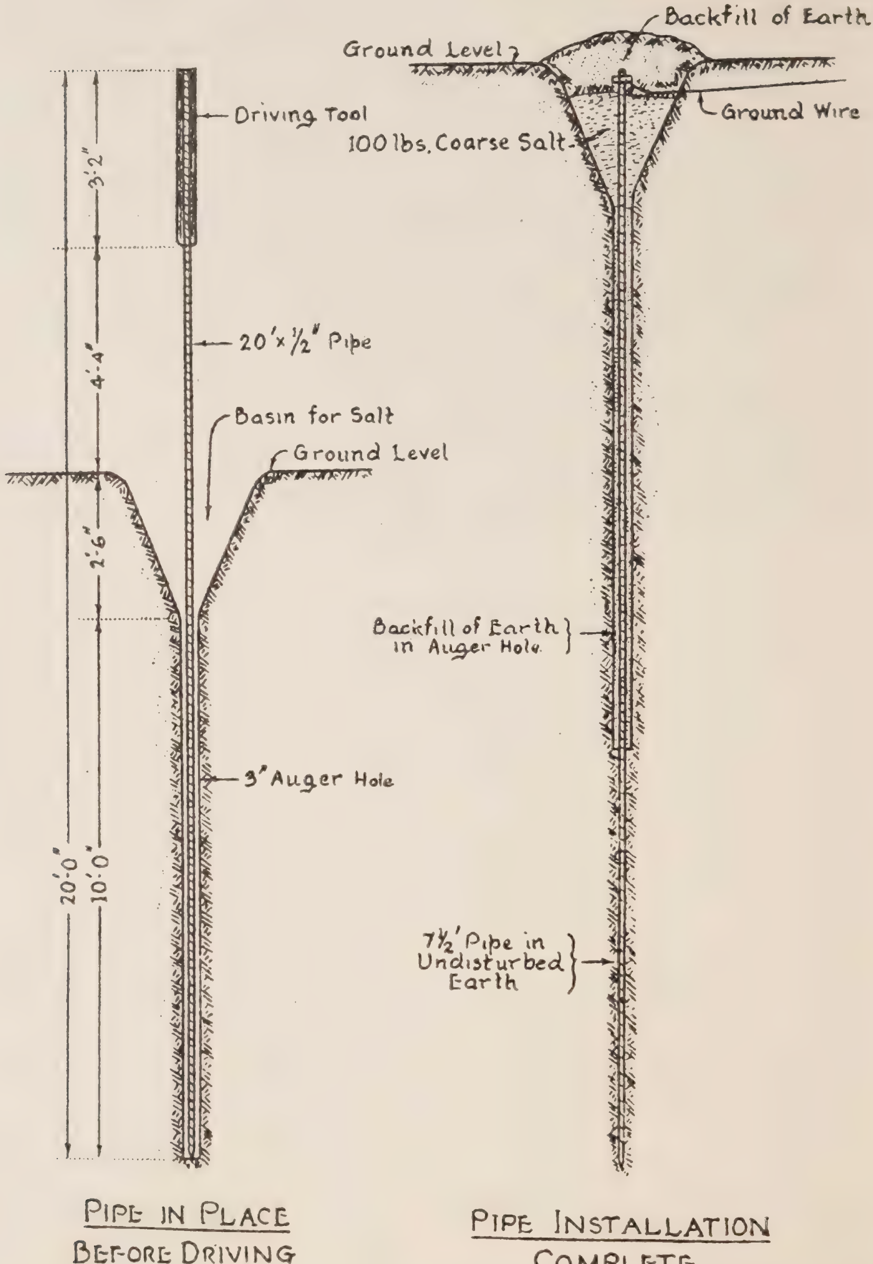


Fig. 2—Basin type method of salt treating a 20 ft. pipe. The method for a 10 ft. rod is similar except that auger is not used.

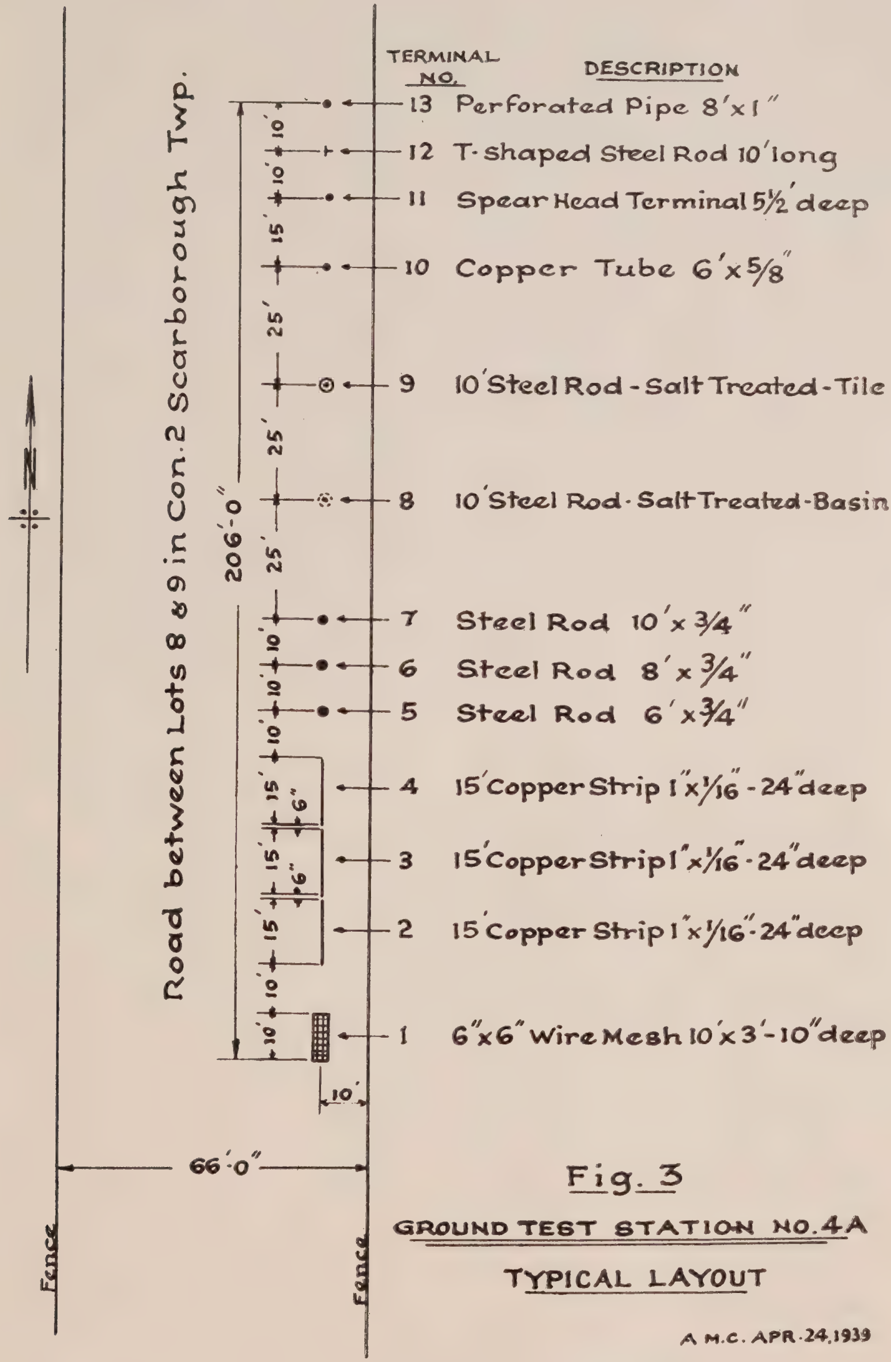


Fig. 3

GROUND TEST STATION NO. 4A

TYPICAL LAYOUT

A.M.C. APR. 24, 1939

½ in., ⅝ in., and ¾ in.

⅝ in. by 21 ft. flush joints—Station No. 3.

¾ in. by 12 ft. coupling joints—Station No. 3.

½ in. by 10 ft. coupling joints—Station No. 3.

¾ in. by 21 ft. flush joints—Station No. 3.

½ in. by 17½ ft. coupling joints—Station No. 4.

⅝ in. by 20 ft. flush joints—Station No. 4.

¾ in. by 21 ft. flush joints—Station No. 4.

The layout of a typical station is shown in Fig. 3.

Description of Test

A—Resistance Measurements

The layout of the stations was such that the resistance tests could be made by setting up the instrument at a point midway between the two extremities. A reel stand was fabricated on which were wound 2—140 ft. rubber covered lead wires and 1—70 ft. lead. With this arrangement any terminal in the group could be tested by using two of the more remote terminals as test probes. In general the same pair of reference terminals were used each time to test any given terminal.

An earth tester with a range of 0—3000 ohms was used for most of the tests, but a higher range instrument was used when values exceeded 3000 ohms. All the instruments used checked fairly closely and no correction factor was necessary when shifting from one to another.

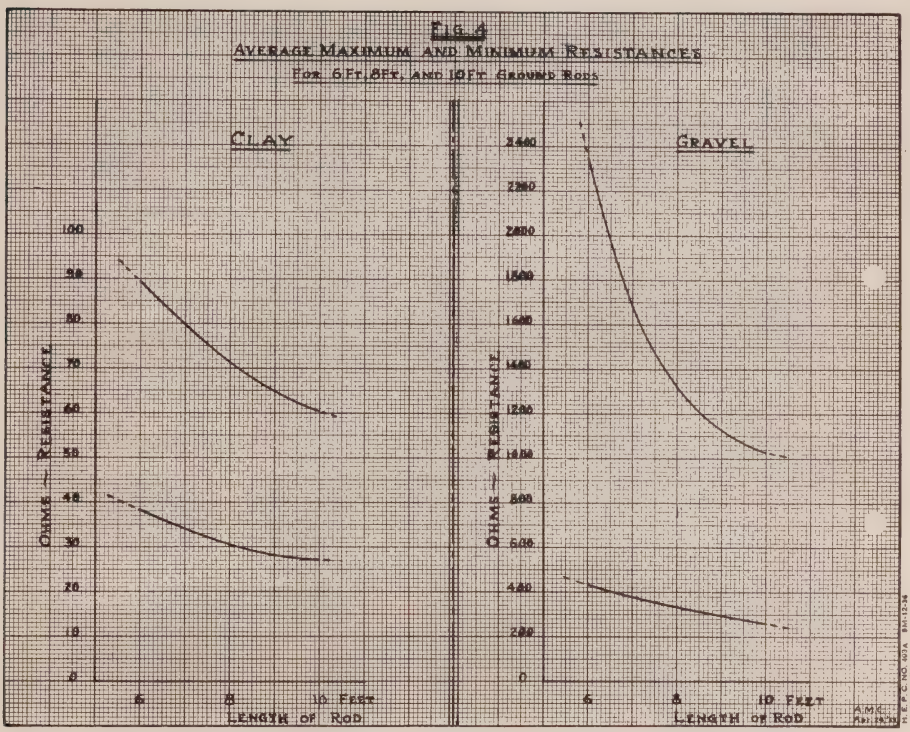
The first test was carried out on July 29, 1932. Weekly tests were made, always on Friday, until Aug. 25, 1933. The reason for carrying the tests on through August 1933 was because of the exceptionally dry, hot weather during the summer of 1933, when the resistances of all terminals were steadily increasing.

On checking over the results it was found that the winter of 1932-33 was not normally severe and additional information was desired. On December 7th, 1933, testing was resumed at fortnightly intervals and continued until March 29th, 1934, when the frost was beginning to leave the ground. Weekly readings were then taken until May 25th, 1934. In addition, tests were made at Stations 2, 2A, 3, 3A, 4 and 4A on April 9th, and 11th, on account of the very changeable weather during that week.

B—Frost Measurement

Since frost penetration was expected to play a very important part in the results obtained, it was desired to get complete and accurate records. With only a few inches of frost it was comparatively simple to pick through and measure the depth of crust, but as the frost went deeper, this method involved a great deal of time and labor.

Various shorter methods of obtaining the depth were then tried, but with little success. A drop hammer arrangement was tried which had provision for measuring the increment of depth for each blow. Other methods attempted involved the change with depth of earth conductivity and temperature, the latter by means of buried thermocouples. In all three cases the desired variations were too small to be measured accurately, and finally digging was reverted to.



C—Rainfall Data

Complete records of precipitation data were obtained from the Meteorological Office. The information for stations 1 and 1A was taken from the Toronto sheets, and for the remaining stations from the Agincourt sheets. Although precipitation includes both rainfall and snowfall, for our purpose the total was taken as inches of rain per week immediately prior to the date of test. To obtain this total, snowfall was converted to rainfall by the relation 10 in. snow = 1 in. rain.

D—Temperature Data

Temperature records for the total period of test were obtained from the Toronto and Agincourt sheets. The temperature shown on the curves is the mean for four days previous to test. The daily mean was taken from the maximum and minimum readings and the listed value is the average of these daily means.

Graphic Representation of Data Obtained

All resistance and associated measurements have been summarized in the form of graphs. A comparison between the 10 ft. ground rod and the former 6 foot standard is shown in Fig. 4.

Seasonal variations of resistance, rainfall, temperature and frost penetration were plotted vertically against a time base on which each division represented one week. Originally, straight cross-section paper was used, but on account of the great range of

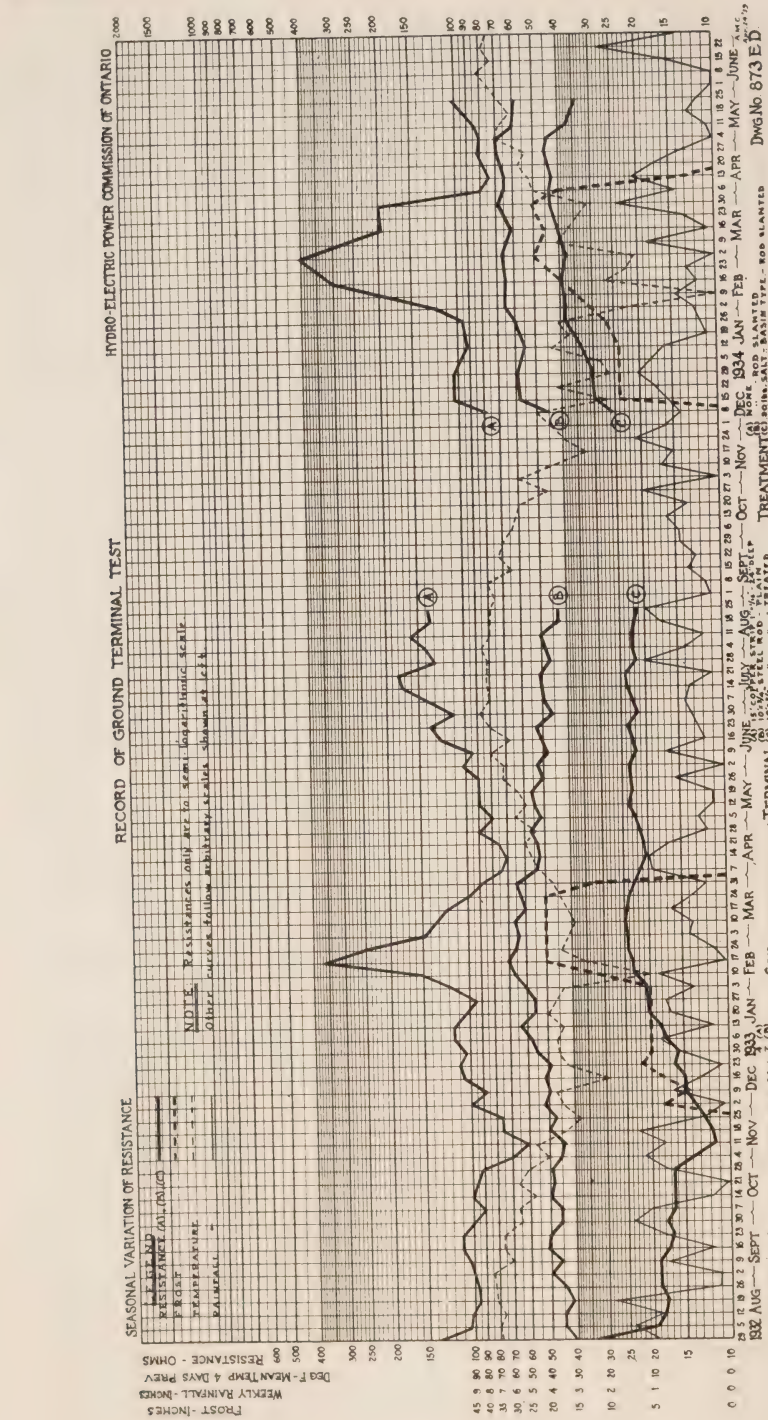


Fig. 5—Seasonal variations in loam.

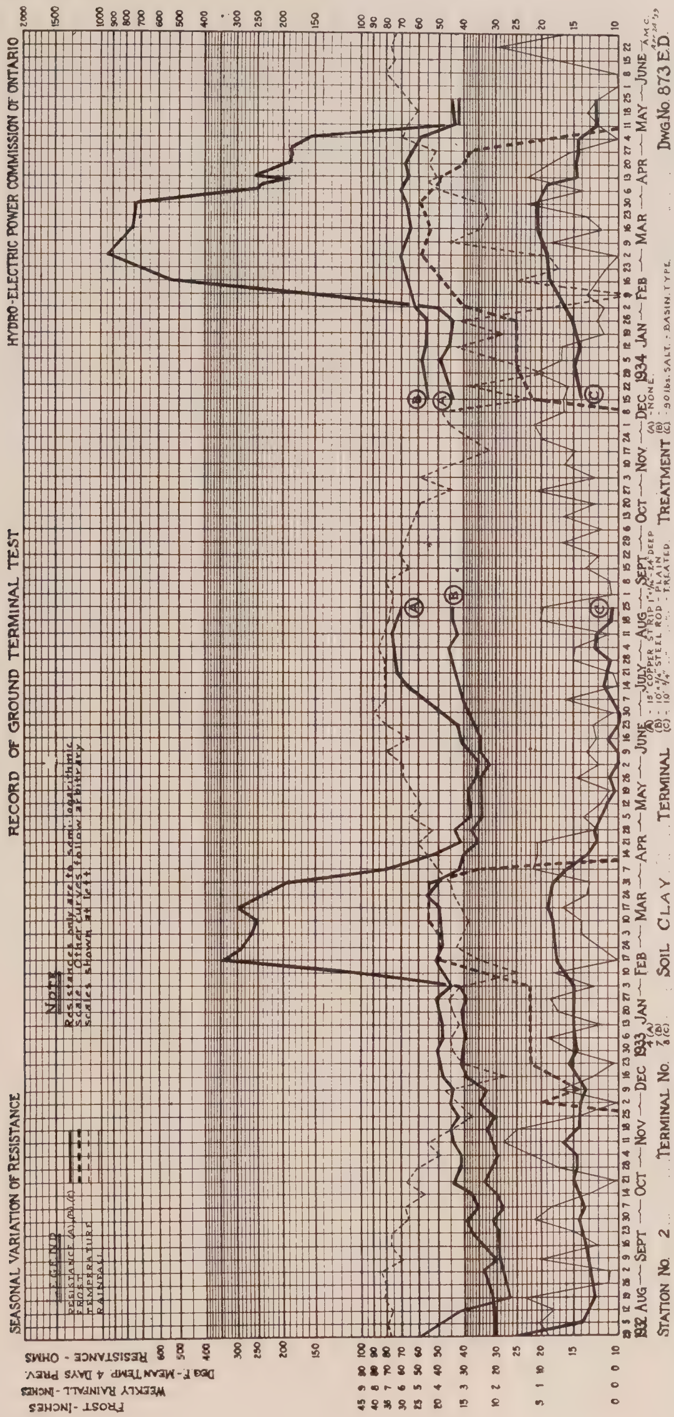


Fig. 6—Seasonal variations in clay.

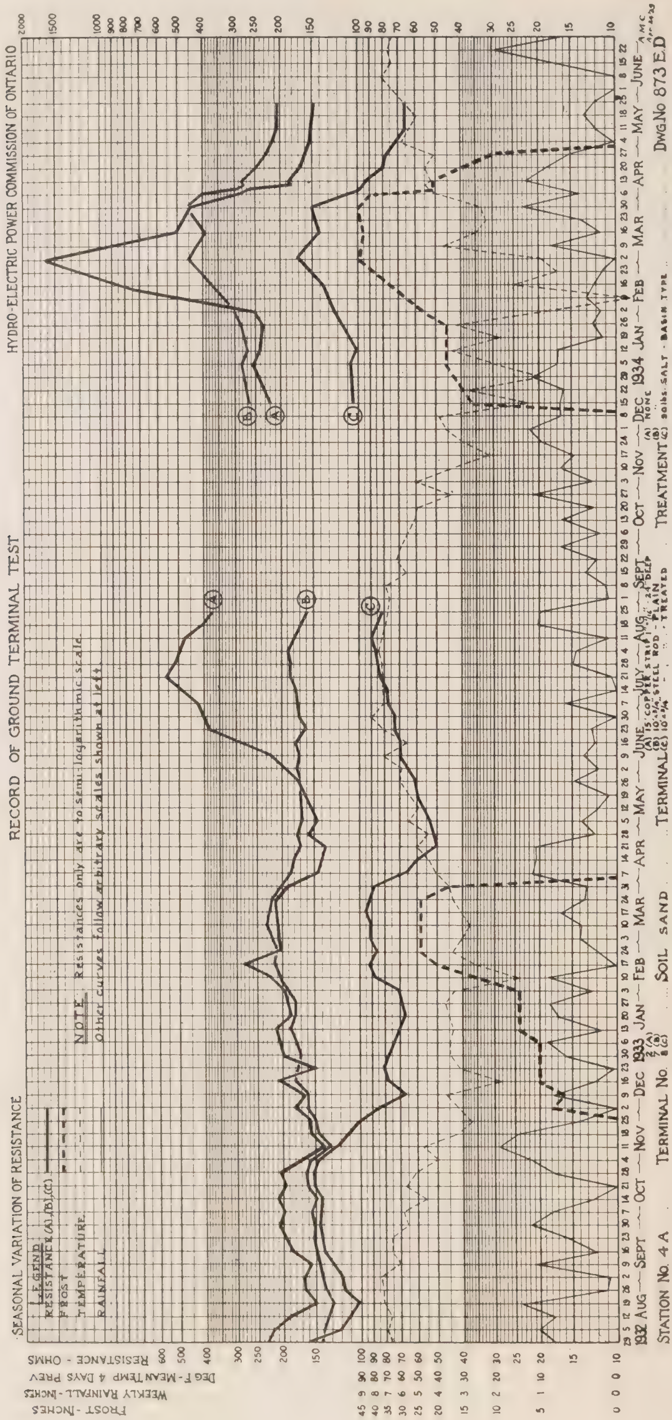


Fig. 7—Seasonal variations in sand.

resistances several different vertical scales were necessary. It was found that by using a logarithmic vertical scale any resistance curve could be accommodated on a sheet of convenient size. A separate sheet was used for each terminal, making 144 in all, and since it is not practical to include the complete set in this paper a few typical charts have been combined and are shown in Figs. 5, 6, and 7.

It should be noted that only the scale for resistance is truly logarithmic while the other scales were chosen arbitrarily. This was necessary to confine the curves to a reasonable range on the sheet and to accommodate zero values of temperature.

SUMMARY OF DATA

(All resistances given in ohms)

A.—MAXIMUM AND MINIMUM VALUES FOR COMMON TYPES OF TERMINALS

Station	Max. Resistance Winter	Max. Resistance Summer	Low Resistance Spring or Fall
Wire Mesh 20 ft. by 3 ft.—10 in. deep.			
1. 4 ft. clay over rock	175	38	15
2. Clay	400	57	17
3. Gravel	1,375	330	80
4. Sand	1,510	380	100
Wire Mesh 10 ft. by 3 ft.—24 in. deep.			
1A. 6 ft. clay over rock	155	83	45
2A. Clay	119	45	19
3A. Gravel	2,760	700	140
4A. Sand	2,750	380	118
¾ in. by 6 ft. steel rod—no treatment.			
1. 4 ft. clay over rock	180	118	88
2. Clay	110	56	38
3. Gravel	2,050	1,225	450
4. Sand	2,700	1,320	500
¾ in. by 8 ft. steel rod—no treatment.			
1. 4 ft. clay over rock	100	95	50
2. Clay	77	48	32
3. Gravel	1,290	750	260
4. Sand	2,600	1,300	510
¾ in. by 10 ft. steel rod—no treatment.			
1. 4 ft. clay over rock	70	53	41
2. Clay	70	45	29
3. Gravel	900	720	200
4. Sand	1,750	875	400
Copper Strip { a—15 ft. length 24 in. deep; b—15 " " " " "; c—15 " " " " "; d—45 " " " " " }			
1. 4 ft. clay over rock a	195	70	40
b	142	111	48
c	400	180	60
d	70	43	19

Station		Max. Resistance Winter	Max. Resistance Summer	Low Resistance Spring or Fall
2. Clay	a	350	54	26
	b	760	82	26
	c	950	76	26
	d	190	25	12
3. Gravel	a	2,010	700	132
	b	2,800	1,050	160
	c	2,300	730	120
	d	910	290	60
4. Sand	a	3,000 plus	1,000	175
	b	3,000 plus	1,500	205
	c	3,000 plus	1,200	185
	d	2,200	460	90
1A. 6 ft. clay over rock	a	250	96	50
	b	205	130	54
	c	270	160	56
	d	87	47	19
2A. Clay	a	110	50	27
	b	60	39	22
	c	109	53	25
	d	30	18	11
3A. Gravel	a	3,000 plus	1,070	155
	b	2,700	930	150
	c	2,500	655	125
	d	1,100	300	59
4A. Sand	a	1,700	560	135
	b	2,350	600	100
	c	2,650	775	125
	d	800	215	50

¾ in. by 10 ft. steel rod—salt treated—basin type.

1. 4 ft. clay over rock	43	24	11.5
2. Clay	20	12.5	10
3. Gravel	700	275	40
4. Sand	400	170	75

In both gravel and sand the charge of salt apparently disappeared during the first year, but the beneficial effect was still evident.

¾ in. by 10 ft. steel rod—salt treated—tile type.

1. 4 ft. clay over rock	80	53	15.5
2. Clay	15.5	11	10
3. Gravel	900	400	60
4. Sand	510	200	95

1 in. by 8 ft. perforated pipe—salt treated.

1. 4 ft. clay over rock	195	115	33
2. Clay	45	28	20
3. Gravel	1,320	795	210
4. Sand	1,030	590	165

⅝ in. by 6 ft. copper tube—salt treated.

1A. 6 ft. clay over rock	100	70	32
2A. Clay	70	40	32
3A. Gravel	2,550	830	280
4A. Sand	1,840	650	175

In both types of perforated pipe the charge of salt disappeared during the first year and its effect gradually became less, the resistance in the second year resembling that of an untreated terminal of equivalent length.

(To be continued)

O. M. E. A. and A. M. E. U.
Summer Convention Programme

The 1940 Summer Convention of the Ontario Municipal Electric Association and the Association of Municipal Electrical Utilities will be held at Bigwin Inn, Muskoka, on July 9th and 10th, 1940. There will be two main sessions at the convention, one on the morning of Tuesday, July 9th and the other on the morning of Wednesday, July 10th. Both of these will be joint sessions of the two associations.

The session on the morning of Tuesday, July 9th, will be devoted to a paper on utility transportation equipment to be presented by H. D. Rothwell, Assistant Engineer, Municipal Engineering Department of the Hydro-Electric Power Commission of Ontario and Chairman of the Commission's Truck Committee. The Committee has made a thorough study of the different types of trucks used by electrical utilities in the United States and Canada and is prepared to discuss suitable equipment for use by the different municipal systems.

On the evening of this day there will be a convention dinner which will be followed by an exhibition of the Commission's sound film entitled "The Bright Path".

On Wednesday morning, July 10th, the session will be given over to an address by K. A. Christie, K.C., Commissioner, Toronto Hydro-Electric Commission, on the relationship of commissioners and utility employees. This will be followed by a paper on fluorescent lighting by a representative of the Canadian Westinghouse Company.

The hotel has quoted the following rates to delegates to the convention beginning on Saturday, July 6th.

$7.00 per person—1st and 2nd floor; all with bath.

$6.00 per person—3rd floor with bath.

$5.50 per person—3rd floor without bath.

25 cent return ferry rate.

Free golf.

Reservations should be made directly with the hotel. Post-card forms for this purpose will be provided for the use of delegates when convention notices are mailed to them.

Inauguration of the C.E.S.A. Approvals Service

THE Canadian Engineering Standards Association has established an *Approvals Division* and has issued a special notice governing the approval of electrical equipment.

To satisfy the repeated requests of a wide representation of Canadian interests, in the electrical field, the C.E.S.A. Executive Committee, in March 1939, authorized the organization of a special division to provide for approval of electrical equipment to be sold or installed in Canada. The C.E.S.A. Main Committee confirmed this action in December, 1939. This proposal met with the unanimous approval of electrical inspection authorities in each of the provinces, and of power supply, manufacturing and electrical interests in general, throughout Canada.

Date of Inauguration — May 1st, 1940

An appropriate organization has been in the course of development during the past year and preparations were completed whereby the C.E.S.A. Approvals Division would be in a position, by May 1st, 1940, to enter into agreements with manufacturers for the purpose of issuing approval of electrical equipment, and provide suitable labels for such equipment where it meets the requirements of the appropriate Specifications of the Canadian Electrical Code, Part II, and of prescribed tests performed by laboratories authorized for the purpose by the C.E.S.A.

Basis of Approvals

Approvals work will be carried out in accordance with the provisions of the Canadian Electrical Code, Part I (current edition) and the supplementary Standard Specifications of the Code, Part II. All current editions of Specifications of the Canadian Electrical Code, Part II, published prior to February 1st, 1940, will be effective for C.E.S.A. approvals purposes as of May 1st, 1940, and all Specifications under that section of the Code published after February 1st, 1940, will be effective as of date of publication or will be otherwise specifically marked as to effective date.

Procedure For Application For Approval

Applications for approval of electrical equipment should be made to the C.E.S.A. Secretary, or to the Approvals Engineer at the addresses indicated below. An Approvals Manual giving general information and detailed instructions as to procedure in seeking C.E.S.A. approval of electrical equipment is being prepared and will be available on request. *Manufacturers are requested to ask for instructions as to the submitting of samples for testing, by applying to:*

The Approvals Engineer,
Canadian Engineering Standards Association Approvals Division,
Room 101; 8 Strachan Avenue,
Toronto.
(Telephone Wa. 6127 or 6128).

or to

The Secretary, Canadian Engineering Standards Association Approvals Division,
3010 National Research Building,
Ottawa.
(Telephone 2-8211: Local 2056).

Follow-Up Inspection Service Agreements

By agreement with the Hydro-Electric Power Commission of Ontario, all *Follow-up Inspection Service* Agreements between the H.E.P.C. and manufacturers or submittors, that, at the time of the transference of Approvals work from the Commission to the C.E.S.A., are valid, will be assigned to the C.E.S.A., which body will thereafter be the responsible party to such agreements, in place of the Commission. As these agreements expire they may be formally renewed between the C.E.S.A. and the other party or parties thereto.

In connection with the *Re-examination Service*, the C.E.SA. will permit its name, together with the number of the Approval Report, to be imprinted upon all *"C.E.S.A. Approved"* electrical equipment, as was done under H.E.P.C. *Re-examination Service*.

Approvals Labels

All existing *Approvals Labels* bearing the name of the C.E.S.A. and the H.E.P.C. that have not yet been used will be accepted by the Provincial Electrical Inspection Authorities until the stocks have been exhausted; thereafter, standard C.E.S.A. labels, only, will be accepted.

Approvals Card Index and Printed List of Approved Equipment of The H.E.P.C., Ontario

The card index record and the printed *List of Approved Electrical Equipment* embracing the details of approvals issued by the Hydro-Electric Power Commission of Ontario and in effect on April 30th, 1940, will be adopted by the C.E.S.A. as of May 1st, 1940, subject to the general provisions of the C.E.S.A. *Approvals Manual* relative to continued effectiveness of approvals.

On and After May 1st, 1940

the C.E.S.A. is prepared to follow the procedure laid down in the C.E.S.A. *Approvals Manual* for the issuing of approvals on electrical equipment for Canadian use. An effort will be made to send a copy of the *Approvals Manual* to all parties known to be interested, but to anyone who does not receive one, a copy will gladly be sent on request.

The C.E.S.A. Approvals Division has agreed to take over and complete those applications for approval which have not on May 1st, 1940, been completed, —as would have been done by the H.E.P.C. under the former arrangement.

Caution

Please do NOT submit samples for testing to the Ottawa office. Ask for instructions as to the location of the laboratory to which they are to be sent. This will obviate unnecessary delay and expense.

Grounding Practice In Electric Systems

With Particular Reference To Protection From Shock

By W. P. Dobson, Chief Testing Engineer,
H. E. P. C. Laboratories, Toronto

(Continued from April)

Ground Electrodes

The efficacy of grounding practice depends predominantly upon the characteristics of the ground electrode, i.e. the actual means of connection between the part to be grounded and the body of the earth. It is possible to destroy completely the protection desired if this factor be not adequately provided for. This is the chief stumbling block in the way of a thoroughly satisfactory solution of the problem and the particular difficulty resides in the variability of the electrical properties of the soil and the meagre knowledge available of ground characteristics. Experience has shown the great difficulties of designing a ground electrode which will meet all requirements under the conditions encountered.

A great deal of theoretical work has been done in the development of formulas for the resistance of many forms of electrode; these are undoubtedly of great help in securing satisfactory results. However, the uncertain factor is the resistivity of the ground which varies so widely with type and condition of soil that extreme caution must be used in applying these formulas; calculations must be supplemented by tests which take local conditions into account. Much useful work has been done by Dwight in developing formulas and practical methods of applying them. A collection of these formulas is given in a paper published in "Electrical Engineering", December 1936.

Types of Electrodes

The Canadian Electrical Code recognizes several types of electrode on the basis of their resistances. The most desirable is that referred to as a grounding system which has a resistance of 6 ohms or less. A metallic water piping system for public supply usually meets this requirement; this is used wherever practicable. Other recognized types of ground electrodes are: metallic water piping systems for private supply if at least 100 feet in length and buried in the soil, the metallic casings of artesian wells (if the casing is not less than 3 inches in diameter) and one or more ground rods (connected in parellel if more than one are used.) Gas piping may, with certain restrictions, also be used for grounding the non-current-carrying metal parts of electrical equipment. Ground electrodes must be placed below the level of permanent moisture; the connection wires from the equipment to the electrode must

be protected from mechanical injury. Special precautions must be taken in the connections between grounding conductors and electrodes; only clamps approved for the purpose may be used.

The Code strongly recommends that all grounds be tested at the time of installation and periodically (say every 5 years) thereafter. In this respect more stringent regulations are in force in other countries—particularly in New Zealand where utilities are required to test grounds periodically or otherwise give proof that low resistances are being maintained. So far as the writer is aware, no attempt is made in Canada to test ground electrode resistances periodically after installation.

The practice of using water supply systems for grounding has, within recent years, been the cause of difficulty between the water supply authorities and the electric utilities. About 10 years ago the American Waterworks Association withdrew its approval of the practice of grounding electrical systems to water supply systems, alleging that the abuse of the privilege on the part of the utilities was resulting in the flow of excessive and destructive currents through the water pipes. The difficulty has been accentuated by recent attempts of the electrical utilities in United States to introduce new methods of wiring in which a bare neutral conductor is incorporated.

Changes in water works practice, involving the introduction of mains of non-conducting material, has also increased the difficulty of obtaining low electrode resistance and may have a revolutionary effect on grounding practice particularly in urban centres.

A committee, known as the American Research Committee on Grounding, was formed a few years ago in the United States and is now investigating the subject in all its aspects.

Rod Electrodes

Rods or pipes driven vertically into the earth are almost universally used for grounding both consumers' circuits and equipment, and in many localities, distribution systems. They offer the advantages of low cost and ease of installation; under favorable soil conditions they may be driven to the permanent moisture level—an important feature in maintaining low electrode resistance.

From the point of view of resistance the material of the electrode is not important, since there is very little voltage drop in the electrode itself. In this district mild steel rods ¾ inch in diameter, 10 feet long and ungalvanized have proven quite satisfactory. The corrosive effect of the soil and of chemicals used to treat the ground are negligible.

The theoretical characteristics of rods may be calculated from the formulas of Dwight previously referred to. Dwight's paper also contains curves which facilitate calculations and have the great practical advantage that attainable ground resistances may be estimated in any case from measurements on a few temporary test grounds.

Testing of Rod Electrodes

The practice of testing the resistance of transformer and consumers' ground electrodes at the time of instal-

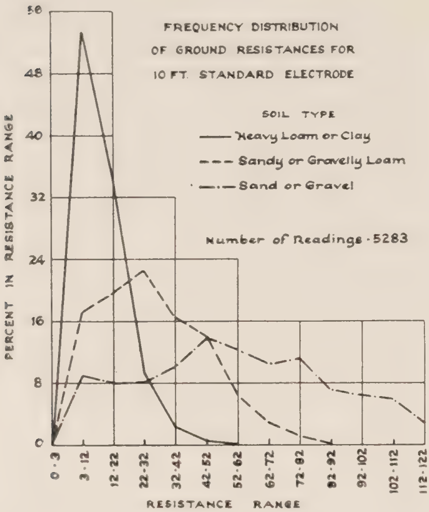


Fig. 1.

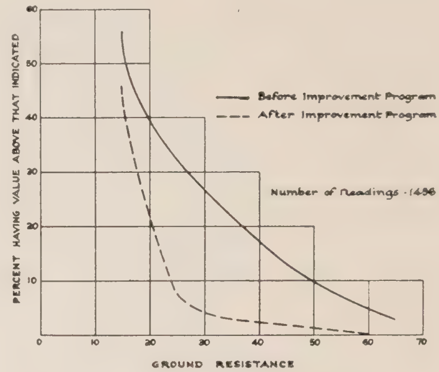


Fig. 2—Curves indicating benefits of ground treatment.

lation is quite general in Canada. In Ontario, measures are taken to obtain, if practicable, resistances of 25 ohms or less in all transformer grounds; either by driving additional rods or by treating the ground with common salt. As a typical example of results achieved, 23,164 grounds were tested in 1934, of which 17,359 were reduced to 25 ohms or less by these methods. In some localities, it is impossible to obtain the desired resistance except at great cost, for example, where rock underlies sand or on gravel hill tops high above permanent moisture level. This condition may not be serious if the neutral is grounded at many points in multiple and has a low overall resistance to ground, this resistance being fairly uniform throughout the system. However, if the ground should be located at the end of a line so that it would be isolated if the neutral wire should break, a special effort is made to reduce the resistance to the minimum value.

The resistance of consumers' grounds is usually tested by the Electrical Inspector, since few wiring contractors are equipped with the necessary measuring instruments. In Ontario, resistances above 25 ohms as required by the regulations are reported to the supply authority, who is expected to reduce the transformer ground resistance to a lower value.

A study of the results of these resistance measurements made over a period of years in Ontario yields interesting information about the possibilities of obtaining low resistances in various types of soil. Fig. 1 shows frequency curves for three types of soil from which it may be inferred that in clay the most probable value of resistance is about 10 ohms, in sandy loam about 30 and in gravel about 50. However, reliance should not be placed on such curves in designing electrodes; they are given merely to show the comparative results obtained in this part of the country. Fig. 2 shows results plotted in a different way and indicates the benefits of ground treatment.

Other Types of Electrodes

Investigations have been conducted by electrical utilities and others in order to compare the characteristics of various types of ground electrode. Such investigations were undertaken in Ontario in 1932, and while the results merely confirm in some respects those obtained elsewhere it is believed a summary may be of interest. They will be discussed in greater detail by E. F. Hinch in a future issue of "The Hydro Bulletin."

Eight test stations were installed in four different classes of soil, and measurements extended over a two-year period. The types of electrodes included:

Wire mesh at various depths.

Copper strips at various depths.

Steel rods 6 feet to 20 feet long, ¾ inch diameter some of which were treated with salt.

Perforated pipes, containing salt solutions.

Several rods of T and star-shaped section.

The stations were located in clay, sand, gravel, and in soil underlaid by rock at several depths, chosen as typical of conditions in Ontario.

Seasonal variations of as much as 2,700 per cent were found for some electrodes. Fig. 3 shows typical results for driven rods.

Maximum values of resistance occurred in midwinter or midsummer, minimum in spring or fall. Precipitation was the most important single factor affecting the resistance.

In localities where a shallow layer of earth lies over rock, a strip electrode is better than a mesh. Frost

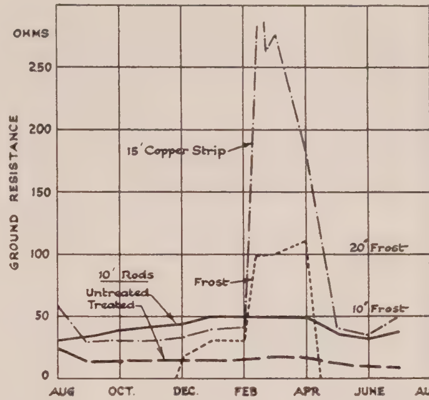


Fig. 3—Typical results for driven rods.

destroys the effectiveness of an electrode. Soil treatment is valuable in reducing resistance; it is most effective in dense soils. It may often be more economical to treat single electrodes than to install additional rods.

A 10 ft. by ¾ in. steel rod would appear to have the best seasonal characteristics for use as an artificial ground. It is usually possible to lower greatly resistance values by driving rods in parallel. Where it is possible to drive longer rods this practice will be found, in many cases, more effective than driving additional rods in parallel.

Characteristics of Electrodes at High Frequency

The effectiveness of a grounding system is determined by its impedance at the frequency of the disturbance. Consequently it is important to ascertain the effects of high frequencies and steep wave front discharges. Considerable research work is still necessary on this subject, but investigations, which have been conducted, show that impedance decreases with

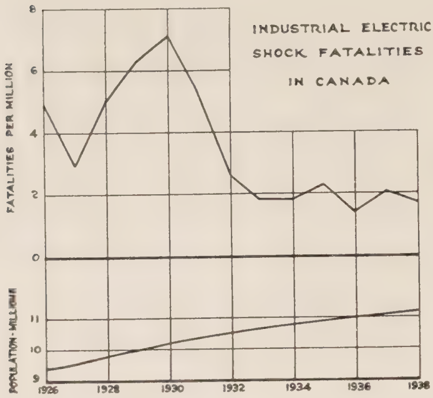


Fig. 4.

increasing frequency, and that in cases where multiple grounds are used the impedance of the interconnecting wires is frequently of great importance and the characteristics of the earth electrode relatively unimportant.

DISCUSSION OF GROUNDING PRACTICE

It may possibly be inferred from this survey of grounding practice that the situation with respect to personal safety is not satisfactory, and that the many exceptions to grounding rules indicate the ineffectiveness of grounding as a means of protection. In this respect judgment must be based upon the results as given in accident statistics and upon the potential hazards which may be deemed to exist, and which are not provided for at present.

Grounding is so intimately connected with the operation of electrical systems that there is no possibility of its being abandoned; the technical arguments in its favor are too weighty. The practice of grounding non-current-carrying metal parts, however, may be subject to modification, and it cannot be concluded that present methods will be continued indefinitely. However, based upon accident statistics, it would appear that the results, in general, are satisfactory. Fig. 4 shows the number of industrial electric shock fatalities in Canada since 1926. It will be noted that since 1932, the ratio is approximately two per million in population. This is a very low value and compares favorably with statistics from other countries. W. Thorn of Melbourne, Australia, reports that in England an average for five years is 2.1; in Switzerland an average for ten years is 6.2, and in several other countries it varies from 4 to 6.7. The Metropolitan Life Insurance Company of the United States reported that from 1913 to 1935 the ratio for its policy holders was 7 per million from electric shock. This was the lowest of six causes of accidents, automobiles being responsible for 40 per million.

From these figures it would appear that the measures taken to protect the public from injury in the use of electricity have resulted in a very satisfactory accident record for electricity as compared with other agencies.

It has been stated by advocates of alternative methods of protection that present methods have failed miserably. This sweeping statement is not borne out by evidence at least in this country.

It must be apparent, however, that no general solution for the problem of grounding exists at present and that alternatives are necessary in certain cases.

The greatest defect in the system is the difficulty of obtaining and maintaining low electrode resistance; this is particularly true in rural areas. In urban districts, large water supply piping systems offer a satisfactory solution, but, as mentioned previously, this may be effected by the introduction of non-conducting piping systems.

The second important difficulty rests in the construction of appliances and their manner of use by the public. Portable appliances particularly deteriorate more rapidly than any other item connected to electric systems. They are less carefully maintained in the hands of the public than equipment in industrial locations and on distribution systems. Carelessness in their use and home repairs are responsible for accidents. Further, certain portions of houses, particularly bathrooms, must be regarded as hazardous locations. The temptation is great to use appliances there, particularly heaters, electric razors, and many new devices rapidly appearing on the market. The provisions of the Canadian Electrical Code for these situations have already been discussed, namely, prohibition, as far as possible, in the use of portable appliances in these locations. This is as far as administrative control can go. Further steps must involve educational efforts to inform the public in the proper use of appliances and it may be said with some confidence that efforts in this direction have produced some results. The greatest possibilities of success lie in the training of school children, and this is a feature which should be emphasized more by educational authorities. In countries, such as Canada where the use of electricity is so widespread, the primary and secondary school curricula should contain courses in the characteristics and use of electrical appliances.

Another objection which has been advanced against the practice of grounding is the possibility that breaks in conductors, particularly neutral conductors on consumers' premises may destroy protection. While this is true, it is also a fact that few cases of breaks in neutral wires have occurred. Only two fatalities have been reported in Ontario on overhead distribution systems caused by breakages in neutral conductors. So far as the writer is aware none have been reported in domestic locations. The regulations, in general, prohibit the grounding of non-current-carrying metal parts to the neutral of identified wire in the consumers' circuit except at the service entrance. The reason for this rule is the fear of breaks in neutral conductors, but in the light of experience there are reasons for permitting this practice in domestic locations.

The chief difficulties in grounding practice are met with in the rural sphere where high ground resistance is most frequently encountered; this introduces a potential hazard which is not present elsewhere. The alternatives provided for in the regulations are not always applicable and other methods will have to be provided. At least two such methods have been proposed and one of them

has been advanced to the stage of commercial application. This is called "Earth Leakage Protection" and consists essentially of a circuit breaker connected to the exposed non-current-carrying metal parts of equipment in such a manner that the power supply will be interrupted if a dangerous voltage should appear on the exposed parts.

This method is recognized in the regulations of the Institution of Electrical Engineers of Great Britain. It was developed in Germany and is in use to some extent on the continent and in Great Britain. In Australia many thousands of installations have been made particularly in the state of Victoria. Theoretically it would appear to offer complete protection irrespective of the value of ground resistance—an advantage not offered by other methods. However, it suffers the same disability as other methods of protection since continuity of the grounding conductor is essential to its successful operation. Its non-selective characteristic is a further disadvantage. However, it is believed that this method warrants more study than has been devoted to it in this country.

The other method referred to also disconnects the supply if voltage should appear on a metal part. It does not require additional conductors as does the earth leakage circuit breaker, but it does require that the consumers' circuits be isolated from other consumers and this will limit its application since a separate transformer would be required for each consumer.

While there is no reason for assuming an alarmist attitude concerning the defects in grounding practice, the situation particularly as it applies to rural localities should not be viewed with complacency. The potential hazards should not be overlooked since they may assume increasing importance as the use of electricity becomes more widespread. Economy should not be the governing factor in deciding upon protective measures. In fact it is difficult to ascertain whether unsatisfactory protection at low cost is the most economical solution. Accidents involving workmen's compensation are often expensive to electrical utilities and to industries, hence their interest in protection should not be determined solely by the initial cost of such protection.

While it may be impossible to reach finality in grounding practice, progress may be made by co-operative effort along several lines:

1. Further progress on an accelerated scale can be made in securing low ground resistance and efforts should be increased in this direction. The statement has been made that more is known about electrical phenomena in the atmosphere than in the ground, and that earth characteristics vary far more widely than atmospheric characteristics. This points to the necessity for more research on ground characteristics, an effort which would be justified in view of the large amount now spent for grounding protection. Much can be done in this field to bridge the gap between theory and practice and to investigate the economic as well as the technical

aspects of the design of ground electrodes. The correlation of ground resistance measurements made in different districts would be an important initial step and should lead to a better understanding of the economics of grounding practice and of the possibilities of securing grounds of low resistance.

2. Alternative methods of protection should be investigated and developed.

3. Standards for materials and regulations respecting installations should be maintained at a high level, as necessary supplements to grounding technique. There is little doubt that the improvements in wiring methods and in the construction of appliances and other equipment, brought about partly by installation and approvals regulations, have been contributing causes of the present fortunate position in Canada with respect to electrical accidents. The wholehearted co-operation of all branches of the electrical industry through the Canadian Engineering Standards Association, is responsible for an important and continuous contribution to public safety.

The author wishes to acknowledge the help given in the preparation of this paper by Mr. E. W. McLeod and Mr. J. R. Leslie of The Hydro-Electric Power Commission Laboratories.

Safety Exhibit

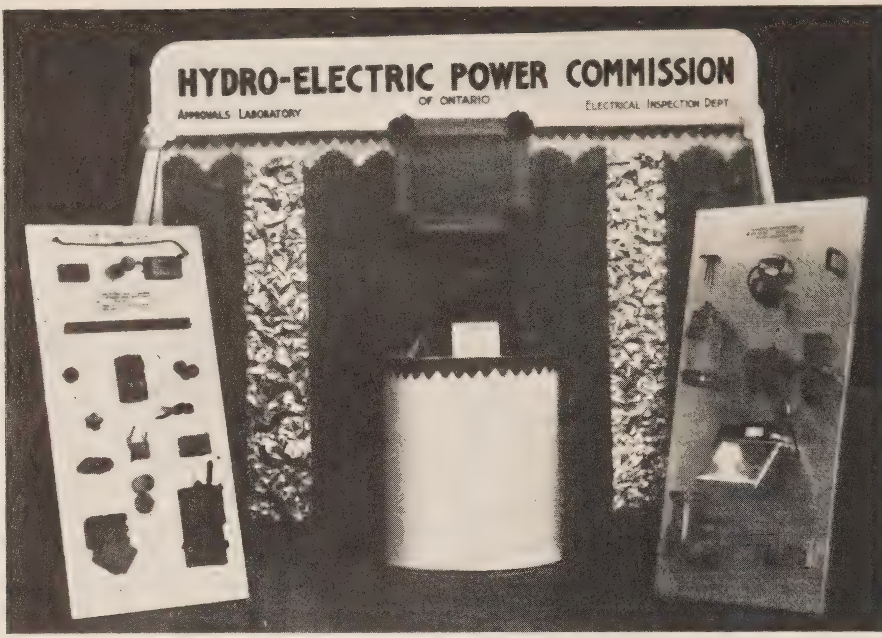
Industrial Accident Prevention Associations, Inc.

**By H. J. McCaw, Sales Control Inspector,
Electrical Inspection Department, H.E.P.C. of Ont.**

THE Silver Jubilee Safety Convention of the Industrial Accident Prevention Associations, Inc., was held in Toronto on April 22nd and 23rd. It was the nineteenth consecutive convention and there was a total attendance of more than 3,400 persons from 129 cities and towns. In Ontario persons attended from Windsor to Renfrew and as far away as Sault Ste. Marie in the north. Out of province visitors were from Detroit, Montreal, Quebec city and Vancouver. At the exhibit, the attendance was 1,861 persons from 559 companies located in 76 cities and towns.

A number of jobbers and manufacturers exhibited equipment and supplies. There were also exhibits by the St. John's Ambulance Association, the Workmen's Compensation Board, the Departments of Labor and Highways of the Ontario Government, the Industrial Accident Prevention Associations, Inc. and The Hydro-Electric Power Commission of Ontario, the latter being in charge of the Electrical Inspection Department.

Exhibited by the Electrical Inspec-



Hydro exhibit at the Industrial Accident Prevention Associations, Inc., convention.

tion Department were a number of ancient fittings and switches, some of which have been removed from service but recently. There were other pieces of substandard equipment which our inspectors had found in service and ordered removed. The Approvals Laboratory supplied a number of pieces of equipment that had been rejected.

One interesting exhibit was a number of coppers which had been removed from fuse holders, these being mounted on a suitable card.

A radio which was badly burned in a fire in Toronto recently was shown. The fire was caused by an extension cord, this being made of four different kinds and lengths of wire, each of which was less than two feet long, the joints being insulated with adhesive tape.

A moving picture titled "Preventing Fires Through Electrical Safety" was also shown. It was obtained from the International Association of Electrical Inspectors, Publicity Department, and dealt with the cause of fires by electricity through carelessness and non-compliance with Code rules.

The attendance was most gratifying to the Association Management, the luncheons taxing the capacity of the Concert Hall and an overflow crowd being at the banquet.

Colonel John Stilwell, a former Canadian, Vice-President of the Consolidated Edison Company of New York and President of the National

Safety Council was the banquet speaker.

The picture, shown herein, was taken by G. M. Neff, Exhibit Manager. Mr. Neff was a former member of the Commission's Staff, having worked in the Hydraulic Department in the days of the Chippewa Canal.

The High Frequency Testing of Insulation Between Turns on Transformer Coils

By C. F. Book, Assistant Meter Engineer, H.E.P.C. of Ont.

THE following is a description of the equipment and procedure used in making insulation tests between turns on the coils of a transformer which was recently rebuilt at Queenston generating station. The preliminary experimental work in connection with the method was carried out in the high voltage test room at Toronto Power transformer station with the co-operation of S. E. Thomson, who already had available most of the equipment necessary for this purpose.

List of Equipment

(1) High voltage transformer 110-220/45000 v., 25 cycles, 5 kw. (short interval rating).

(2) Rotating spark gap consisting of two metal discs 6 inches in diameter and ½ inch thick driven in opposite directions at about 3000 rev. per min. by means of an electric motor.

(3) High voltage condenser, 45000 v., micanite dielectric, oil immersed. 7 sections of 0.0033 microfarad capacity per section.

(4) High frequency coil consisting of two to four turns of No. 0 copper, space wound on a 22 by 34 inch wooden frame and provided with means for rotation about an axis through the centre line of the longer dimension.

(5) A resistance load box capable of limiting the current from the 110 or 220 v. supply to about 10 amperes.

(6) A high frequency choke consisting of a 54 turn coil of No. 14 switchboard wire. Mean diameter of coil approximately 10 inches.

(7) A calibrated sphere spark gap.

In addition to the above, miscellaneous items are required such as, wooden horses for supporting the coil under test, pieces of plate glass to act as insulating spacers, Neon tube potential testing device, connecting wire, etc.

Description of Set-up

The photographs (Figs. 1 and 2) and the diagram of connections (Fig.

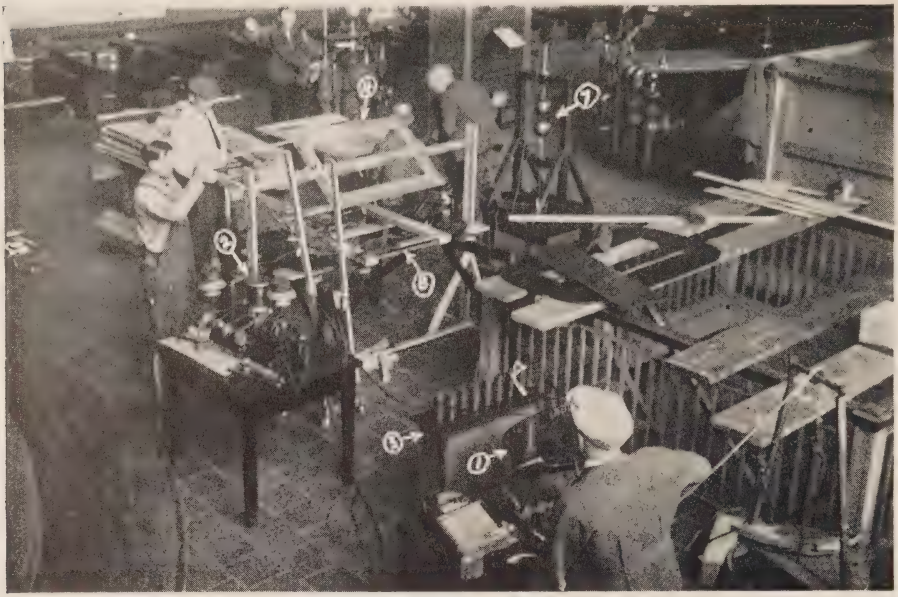


Fig. 1—Showing between turn insulation tests in progress on rebuilt transformer coils.

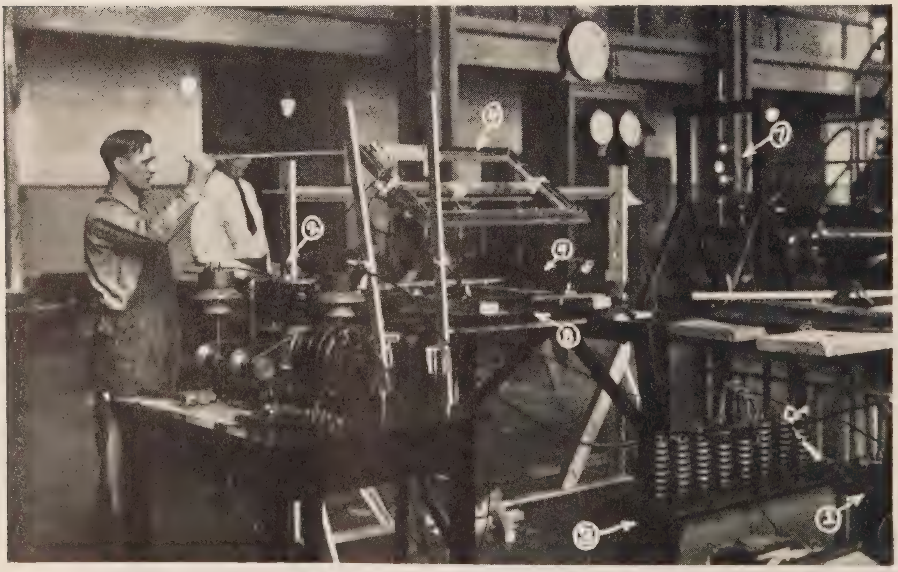


Fig. 2—The high frequency coupling has been increased and the protective gap is sparking over.

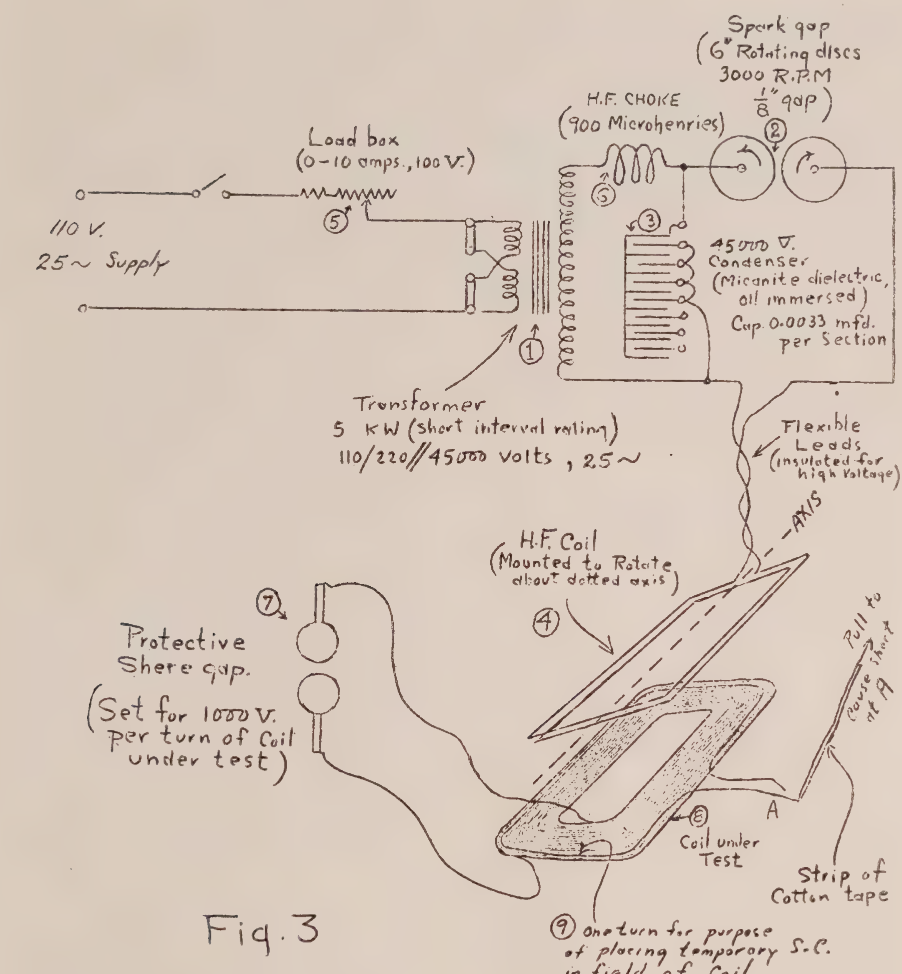


Fig. 3

Diagram of Connections for High Frequency testing of between turn insulation on Transformer Coils.

3), give a general idea of the set-up.

In Fig. 1 the coil (8) under test can be seen lying flat on the horses under the high frequency coil (4). The angular position of the high frequency coil determines the relative amount of flux from this coil which will link the coil under test. This angle can be controlled while the circuit is alive by means of the long insulated handle extending outward from the wooden frame of the coil. The sphere gap (7) can be seen on the far side, while the motor driven spark gap

(2), condenser (3), transformer (1), etc., are in the foreground.

A single turn of wire (9) is laid over the coil under test for the purpose of duplicating the effect of a faulty turn. The ends of this wire are brought out in such a manner that they may be brought into contact with each other by pulling on a long piece of cotton insulating tape tied to one of the ends. This single turn for producing an artificial fault is separated from the coil under test by pieces of plate glass.

Procedure in Making a Test

Suppose the equipment is set up in accordance with Fig. 3 and we are carrying out tests on 60 turn coils at 1000 volts per turn.

A coil to be tested is placed in position as shown in Fig. 1 and connected to the sphere gap which has been set for 60,000 volts. Everything is carefully checked to be sure that everything is clear of the high tension circuits. The rotary spark gap is then set in operation and the transformer is made alive. This sets the high frequency oscillating circuit in operation. The coupling between the high frequency coil and the coil under test is now increased to its normal position, at which position the sphere gap sparks over. The artificial fault is now placed on the coil by pulling on the cotton tape and the sparking of the sphere gap immediately ceases. The sphere gap immediately sparks over again upon release of the artificial short circuit. The above behavior is taken as indication that the coil is satisfactory, for if a coil is faulty, the sphere gap can not be made to spark over even when the coupling of the high frequency coil is increased considerably beyond its usual position.

When testing a particular group of coils it may be found that the natural period of the coils has a critical value in relation to the test frequency. When this is the case voltage nodes, within the coil under test, may appear which can be detected by checking the potential gradient across the coil by means of a Neon tube potential indicating device (see Appendix). If a particular group of coils exhibits this behavior it is necessary to adjust the test frequency to a different value by cutting in or out one or two of the condenser sections or by changing the number of turns in the high frequency coil. In cases like the above it is sometimes possible to get a reversed action and to find that the sphere gap spills over when the short is applied. However, once a satisfactory frequency has been selected it should require no further adjustment when testing a particular group of coils.

Theory of Operation

While the 25 cycle voltage wave is increasing to the breakdown value of the rotating gap the condenser is being charged and when the gap arcs over a low resistance oscillating circuit is completed between the condenser and high frequency coil. A damped wave train is produced at the resonant frequency of the circuit but it is interrupted by the blowing out of the arc as soon as the 25 cycle voltage falls to zero. The process is repeated every half cycle. The peak value of the voltage across the generating high

frequency coil is the same as the potential across the condenser at the moment the rotating gap breaks down. The voltage in the generating high frequency circuit is therefore determined by the breakdown voltage of the rotating gap.

The voltage induced in the coil under test is dependent upon the mutual flux linking the two circuits and turn ratio between the high frequency generating coil and the coil being tested.

A shorted turn in the coil under test shields the coil from the field of the generating coil and the induced voltage is then insufficient to cause spark over of the sphere gap.

APPENDIX A

The Neon tube potential indicating device consisted of an ordinary 110 to 220 volt circuit tester tied crossways on a long switch stick in such a way that its leads could be brought close and parallel with any successive pair of turns in the coil under test thus forming an electrostatic coupling for the Neon tube.

If an undesirable critical condition exists, the potential, as indicated by the brightness of the Neon tube, will not be uniform when the device is moved across the coil from the outer to the inner turns.

APPENDIX B

When testing the one group of coils, the high frequency coil had only two turns connected. The inductance was then approximately 7.3 microhenries. Adding an allowance of 3.5 microhenries for the leads in the high frequency circuit gives a total inductance of 10.8×10^{-6} henry.

Three condenser sections were used at this time giving a capacity of 3×0.0033 microfarad $= 0.99 \times 10^{-8}$ farad.

The resonant frequency based on the above would be

$$f = \frac{1}{2\pi \sqrt{lc}} = \frac{1}{2\pi \sqrt{10.8 \times 0.99 \times 10^{-14}}} = 487 \text{ kc.}$$

Although this is not in the standard radio broadcast band it was nevertheless thought that some local radio interference might be produced by the tests. Attempts at tuning in any such disturbance on an automobile radio in the vicinity while the tests were in progress were, however, without success.

Order from

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The Hydro-Electric Power Commission of Ontario

THE BULLETIN

Published by

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The Thirty-second Annual Report

THE Thirty-second Annual Report of The Hydro-Electric Power Commission of Ontario has been released and distributed to the co-operating municipalities.

Although the work of the Commission and the service it renders to Ontario municipalities has increased tremendously during the past 20 years, the size of the Annual Report has remained very much the same. This has been accomplished by a steady process of condensation. In view of war conditions the 1939 Report is somewhat smaller than in recent years. Certain interesting but not essential material has been eliminated for the time being, reducing the Report by nearly 100 pages.

In spite of its reduced size, the large volume of statistical data included in the Report will be appreciated when it is understood that, in addition to the reports and general financial statements respecting the Commission's work called for by The Power Commission Act, the Annual Report also contains balance sheets and operating reports for more than 290 co-operating municipal Hydro utilities; details respecting the cost of power supplied to the utilities; tables of the rates for service to consumers, for all urban utilities as well as for 184 rural power districts, and detailed information covering the average cost of service, etc. These valuable continuing records of the operation of the local Hydro utilities extend over the past 25 years.

Dr. T. H. Hogg, Chairman and Chief Engineer, in the Introduction to the Report explains that, notwithstanding the tense European situation which over-shadowed activity everywhere, the fiscal year of The Hydro-Electric Power Commission of Ontario which ended October 31, 1939, was a year of encouraging progress. Evidence of the increasing industrial activity throughout the Province was

CONTENTS

Vol. XXVII No. 6
June, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

reflected in increasing power loads. In fact for some months prior to the declaration of war the Hydro experienced substantial increases in loads, and not Hydro alone but other electric supply organizations across Canada. Since the war started these increases in load not only continued but were augmented as plants manufacturing war materials gradually increased their production.

The Bulletin of January 1940 gave a summary of data covering the loads and finances of the Commission for the period covered by the Report, and accordingly we are not repeating them here. Reference was also made to the Commission's war efforts, sales promotion work, service to mining loads and the growth of the rural systems.

CAPITAL INVESTMENT

The total investment of The Hydro-Electric Power Commission of Ontario in power undertakings and hydro-electric railways is $321,214,964.50 exclusive of Government grants in respect of construction of rural power districts' lines ($16,596,670.63); and the investment of the municipalities in distributing systems and other assets is $124,907,581.46, making in power and hydro-electric railway undertakings a total investment of $446,122,544.96.

RESERVES OF COMMISSION AND MUNICIPAL ELECTRICAL UTILITIES

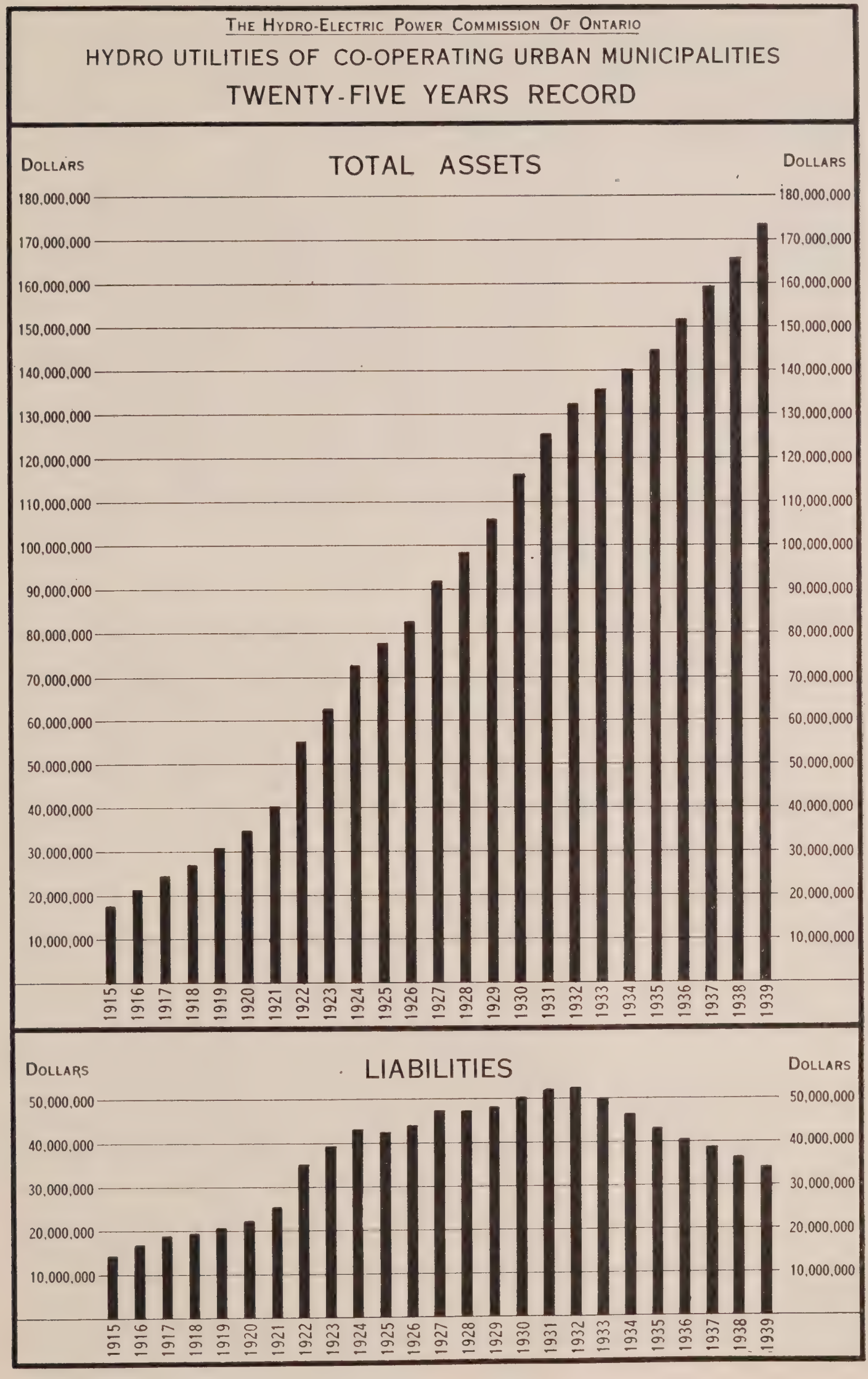
The total reserves of the Commission and the municipal electrical utilities for depreciation, contingencies, stabilization of rates, sinking fund and insurance purposes amount to $216,405,116.02.

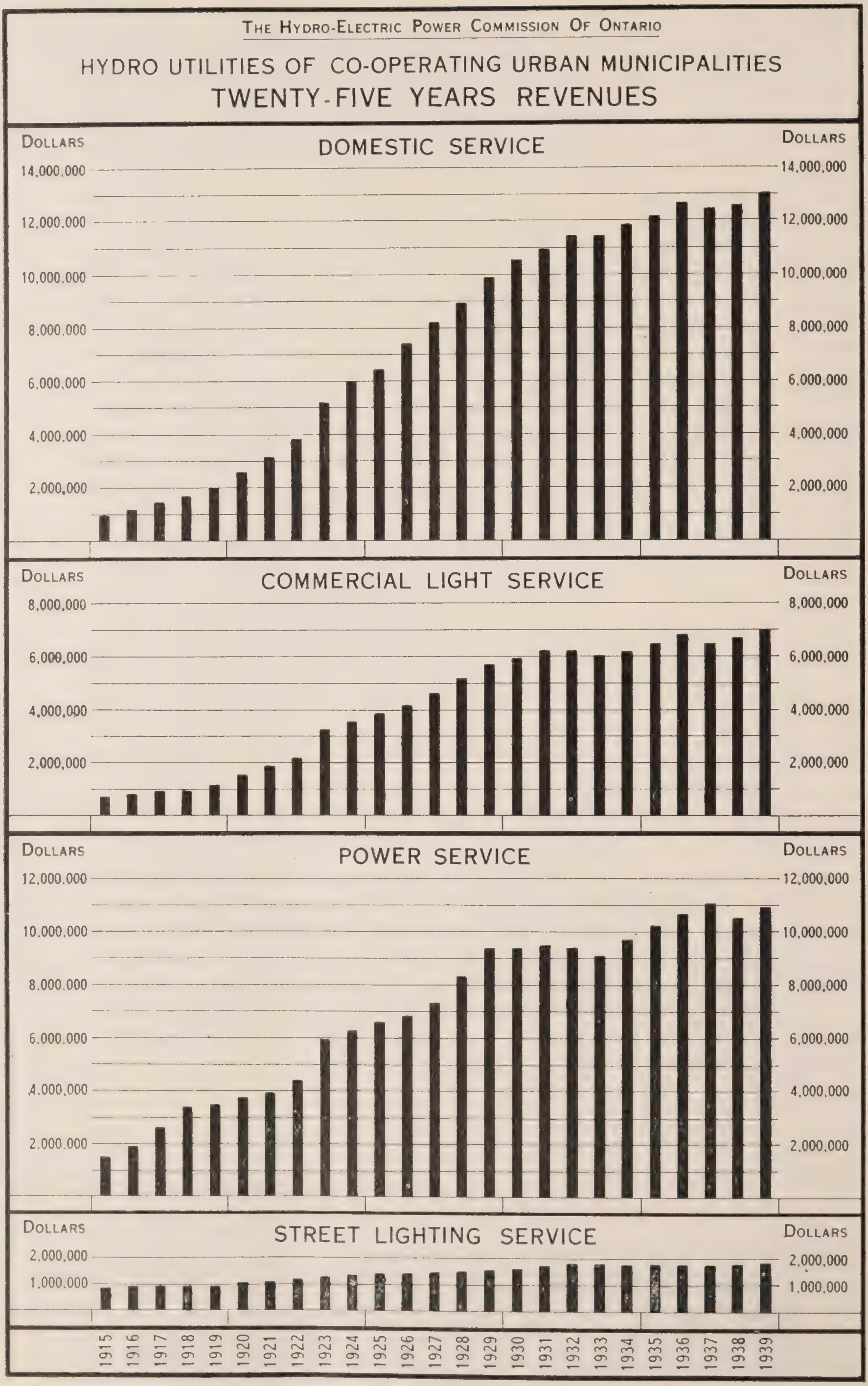
25 YEARS' RECORD OF PROGRESS

In the Foreword to the Report several interesting diagrams covering the past 25 years' record in Ontario well illustrate the financial stability of the Hydro enterprise. Two of these showing the growth of the Hydro utilities of the co-operating urban municipalities are reproduced herein.

MUNICIPALITIES SERVED

At the end of 1939 the Commission was serving 856 municipalities in Ontario. This number included 26 cities, 103 towns, 300 villages and police villages and 427 townships.


THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO
HYDRO UTILITIES OF CO-OPERATING URBAN MUNICIPALITIES
TWENTY-FIVE YEARS RECORD
TOTAL ASSETS
DOLLARS
180,000,000
170,000,000
160,000,000
150,000,000
140,000,000
130,000,000
120,000,000
110,000,000
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939
LIABILITIES
DOLLARS
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939


The Hydro-Electric Power Commission Of Ontario
HYDRO UTILITIES OF CO-OPERATING URBAN MUNICIPALITIES
TWENTY-FIVE YEARS REVENUES
DOMESTIC SERVICE
COMMERCIAL LIGHT SERVICE
POWER SERVICE
STREET LIGHTING SERVICE
Dollars
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
1,000,000
1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939

With the exception of 14 suburban sections of townships known as "voted areas", the townships and 117 of the smaller villages are served as parts of 184 rural power districts.

MUNICIPAL ELECTRICAL UTILITIES

The following is a summation of the year's operation of the local electrical utilities conducted by municipalities receiving power under cost contracts with the Commission:

Total revenue collected by the municipal electrical utilities		$35,289,790.70
Cost of power	$21,855,595.20	
Operation, maintenance and administration	6,028,440.01	
Interest	1,594,040.32	
Sinking fund and principal payments on debentures	2,420,441.30	
Depreciation and other reserves	2,524,364.33	
Total		34,422,881.16
Surplus		$ 866,909.54

With regard to the local Hydro utilities operating under cost contracts, the following statements summarize for each of the four co-operative systems administered by the Commission, the financial status and the year's operations.

NIAGARA SYSTEM

The total plant assets of the Niagara system utilities amount to $83,841,-361,16. The total assets, including an equity in the H-E.P.C. of $42,131,-257.65 aggregate $146,997,350.25. The reserves and surplus accumulated in connection with the local utilities, exclusive of the equity in the H-E.P.C., amount to $73,918,531.93, an increase of $4,576,674.81 during the year 1939. The percentage of net debt to total assets is 21.0 a reduction of 3.4 per cent.

The total revenue of the municipal electrical utilities served by this system was $28,558,726.63, an increase of $990,889.85 as compared with the previous year. After meeting all expenses in respect of operation, including interest setting up the standard depreciation reserve amounting to $2,-024,001.22 and providing $2,244,851.-41 for the retirement of instalment and sinking fund debentures, the total net surplus for the year for the municipal electrical utilities served by the Niagara system amounted to $661,-463.52, as compared with $655,157.82 the previous year.

GEORGIAN BAY SYSTEM

The total plant assets of the Georgian Bay system utilities amount to $2,-963,164.42. The total assets, including an equity in the H-E.P.C. of $1,-556,477.57 aggregate $5,087,865.66. The reserves and surplus accumulated in connection with the local utilities, exclusive of the equity in H-E.P.C., amount to $3,131,173.05, an increase of $43,585.36 during the year 1939. The percentage of the net debt to total assets is 11.9, a reduction of 0.4 per cent.

The total revenue of the municipal electrical utilities served by this system was $1,262,884.52, an increase of $22,794.81 as compared with the previous year. After meeting all expense in respect of operation, including inter-

est, setting up the standard depreciation reserve amounting to $91,562.00 and providing $45,147.28 for the retirement of instalment and sinking fund debentures, the total net loss for the year for the municipal electrical utilities served by the Georgian Bay system amounted to $26,897.01 as compared with a surplus of $75,450.57 the previous year.

EASTERN ONTARIO SYSTEM

The total plant assets of the Eastern Ontario system utilities amount to $9,149,235.27. The total assets, including an equity in the H-E.P.C. of $2,216,217.14, aggregate $13,968,432.79. The reserves and surplus accumulated in connection with the local utilities, exclusive of the equity in H-E.P.C., amount to $9,601,338.05, an increase of $498,720.88 during the year 1939. The percentage of net debt to total assets is 11.6, a reduction of 0.7 per cent.

The total revenue of the municipal electrical utilities served by this system was $3,756,724.57, an increase of $220,165.01 as compared with the previous year. After meeting all expenses in respect of operation, including interest, setting up the standard depreciation reserve amounting to $244,696.81 and providing $109,910.04 for the retirement of instalment and sinking fund debentures, the total net surplus for the year for the municipal electrical utilities served by the Eastern Ontario system amounted to $162,451.40 as compared with $243,365.46 the previous year.

THUNDER BAY SYSTEM

The total plant assets of the Thunder Bay system utilities amount to $2,765,875.55. The total assets, including an equity in the H-E.P.C. of $2,711,344.58, aggregate $6,518,524.21. The reserves and surplus accumulated in connection with the local utilities, exclusive of the equity in H-E.P.C., amount to $3,285,462.74 a decrease of $64,771.10 during the year 1939. The percentage of net debt to total assets is 9.8 an increase of 0.3 per cent.

The total revenue of the municipal electrical utilities served by this system was $1,239,241.83, an increase of $60,066.24 as compared with the previous year. After meeting all expenses in respect of operation, including interest, setting up the standard depreciation reserve amounting to $46,174.94 and providing $10,450.26 for the retirement of instalment and sinking fund debentures, the total net loss for the year for the municipal electrical utilities served by the Thunder Bay system amounted to $11,352.00, as compared with a net loss of $16,900.17 for the previous year.

Safety Glass for Motor Vehicles

By H. F. Davidson, Photometric Section, H.E.P.C. Laboratory

THE last few years have seen the universal adoption of safety glass for the glazing of motor vehicles. Like other manufactured products, its conformance to specifications is determined by test. This article will be confined to a description of the two types of safety glass and the various tests to which they are subjected.

Safety glass is made by treating or combining glass with other substances so that when fractured it will not fly into fragments that may cause severe cuts. The two types of glass used for motor vehicles are laminated and heat-treated.

Laminated Glass

Laminated safety glass was first invented in 1905 by John Crewe Woods. It consists of two layers of glass held together by an intervening layer or membrane of plastic material. Some plastics that have been used are cellulose nitrate, cellulose acetate and acrylate resin. The brown discolouration so evident in early safety glass was due to the action of sunlight on the plastic. The cellulose acetate plastic was used by some manufacturers as it was not subject to discolouration by the sun's rays to the same extent as cellulose nitrate. The discolouration was also greatly reduced by the use of a special glass with a higher iron content which absorbed the harmful rays of the sun and thereby protected the plastic.

A decided improvement in laminated safety glass was the development, a few years ago of vinyl plastic. This plastic is made by compounding Vinylite and a plasticizer and is used by most safety glass fabricators on this continent. The compound is converted into sheets by pressing into blocks and slicing to the desired thickness or by reducing with the addition of volatile solvents, extruding through an orifice and drying to eliminate the solvents. The plastic is then placed between sheets of glass and subjected to heat and pressure which causes the plastic to adhere to the glass. The new plastic practically eliminates discolouration, and has a greater strength at all temperatures. It also has a high resistance to moisture and does not require the sealing of the edges as was necessary with most of the older glasses. To cut the glass to size, it is scored and cracked on both sides and pulled apart sufficiently for the insertion of a razor blade to cut the plastic.

Laminated glass is generally made in three different grades, namely, plate, sheet and a combination of plate and sheet. Plate glass is ground and polished on both sides to approximately plane and parallel surfaces. Sheet glass has the original fire finish on both sides or ground and polished on one side only. The better grades of sheet glass are equal to plate glass with regard to distortion of vision.

HEAT TREATED GLASS

Heat treated glass is ordinary plate glass which has been subjected to a "toughening" process that results in a large increase in strength. This glass is known by several trade names such as "Armourplate," "Securit" and "Triplex Toughened."

During manufacture, the glass is first cut to size as it cannot be worked to any extent after treatment. It is then suspended by tongs and placed in a furnace. After the glass has been uniformly heated to the softening temperature, it is removed and rapidly cooled by blowing air on both surfaces. The heating and cooling processes must be very carefully controlled to assure a uniform product of high quality.

The rapid cooling chills the surface layers of the glass which in their attempt to contract about the core, commence to stretch and continue to do so until solidified. The core, which is still very hot, due to the poor thermal conductivity of glass, will then gradually cool and attempt to contract. The restraint of the solidified surfaces on the contraction of the core results in what might be termed a glass sandwich in which the outer layers are in compression and the centre is in tension. It is believed that this three-layer structure is responsible for the great strength of heat-treated glass.

When heat-treated glass is broken at any point, the whole piece will break into small granular fragments. This is due to the fact that removal of a chip from one of the outer compression layers of the highly stressed glass upsets the balance and causes the glass to shatter. The size of the fragments of the broken glass will depend on the intensity of the stresses which, in turn, depend on such characteristics as the rate of cooling, thermal conductivity of the glass, its specific heat, etc.

The facts that heat-treated glass has a very high resistance to fracture by impact and when fractured breaks into small fragments, none of which have sharp edges, make it suitable for use as safety glass in motor vehicles. It can also be made in the form of curved sheets with less difficulty than laminated glass.

SAFETY GLASS TESTS

There are several tests which are applied to safety glass depending on the particular specification adopted. The most widely used specifications are those of the American Standards Association and the British Standards Institute. As there is no such thing as ideal safety glass, specifications could not be arbitrarily established but were based on the results of tests of good quality glass of the different manufacturers and which was made by standardized and reproducible processes.

The tests required by the American Standards Association are:—

1. Discolouration test.
2. Humidity test.
3. Boil test.
4. Ball drop (10 feet) test.
5. Fracture test.
6. Shot bag test.
7. Dart test.
8. Ball drop (16 feet) test.
9. Visibility distortion test.

Heat treated glass must comply with tests Nos. 1, 2, 3, 4, 5, and 6.

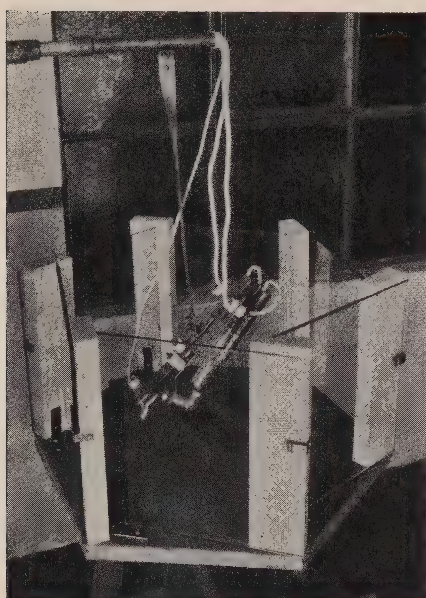


Fig. 1—Equipment used for discolouration test on safety glass. The quartz mercury arc lamp is located over the centre of the turn-table. A fan serves the double purpose of rotating the turn-table and cooling the glass samples.

Laminated glass must comply with Nos. 1, 2, 3, 7 and 8 for side and rear windows and also No. 9 when used for windshields.

The present specifications are not final but may be amended from time to time as improved products and better testing methods become available.

Discolouration Test

This test is conducted in order to determine, in a short time, the effect of exposure of the glass to sunlight. A powerful source of ultra-violet radiation, such as a quartz mercury arc lamp supplies the necessary radiation for this test. The equipment is illustrated in Fig. 1. The glass, each specimen of which has ⅔ of its area exposed, is held in a frame on the turn-table. Uniform exposure on all specimens is obtained by rotating the turn-table. Due to the heat of the lamp, it is necessary to cool the glass with a fan during the test.

After the required period of irradiation, the percent transmission of the exposed and unexposed areas of the glass is measured. The discolouration is generally very slight and noticeable only when the glass is placed on a white background. A few years ago a good quality safety glass would lose about 2 or 3 percent in transmission factor due to exposure to the ultra-violet. Improved plastics have reduced this practically to zero.

Following the exposure to the ultraviolet, the specimens are immersed in boiling water for a short time as a check on any possible reaction due to the ultra-violet which may not be otherwise noticeable. Should bubbles or other decomposition take place, it would constitute a failure.

Humidity Test

The object of the humidity test is to determine the ability of the glass to withstand moisture in the atmosphere for an extended period. The specimens are maintained at a relative humidity of approximately 70 percent for two weeks.

Satisfactory glass will show no separation of materials other than occasional small spots close to the edges.

Boil Test

The boil test is used to determine

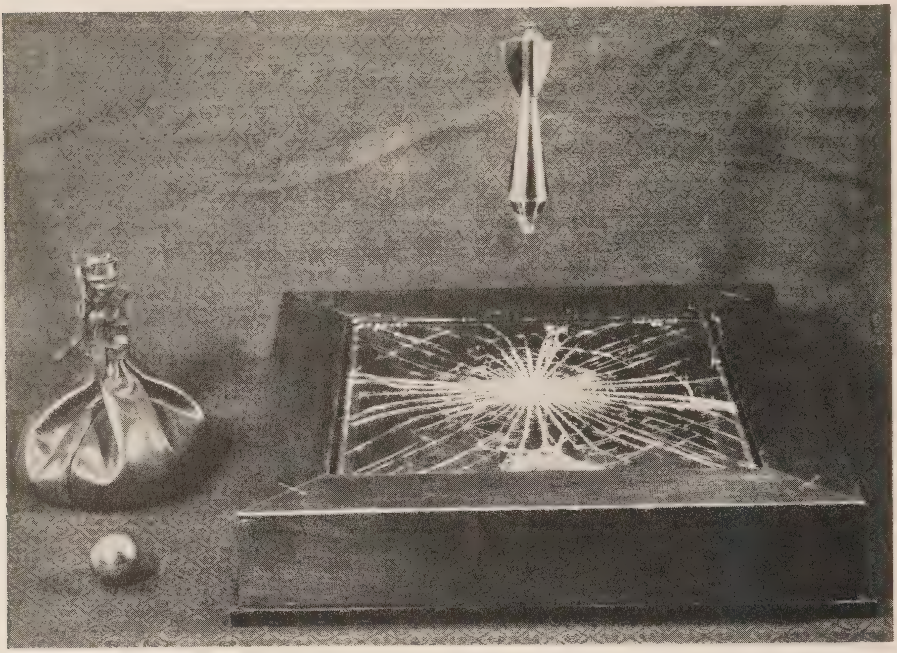


Fig. 2—Impact test equipment. The dart weighs 7 ounces, the ball 8 ounces and the shot bag 11 pounds.

the ability of the glass to withstand high temperatures. As this is not a thermal test, the specimens are preheated and then immersed in boiling water for two hours. There must be no separation of the glass from the plastic.

Ball Test (10-foot drop)

The ten foot ball test is made on heat-treated glass to determine whether it has a certain minimum strength. A one-half pound steel ball is dropped from a height of 10 feet on the centre of the 12-inch specimen supported in a wooden frame. Fig. 2 shows the frame and ball used in this test.

This test is conducted on a relatively large number of specimens which must withstand the impact without cracking or breaking.

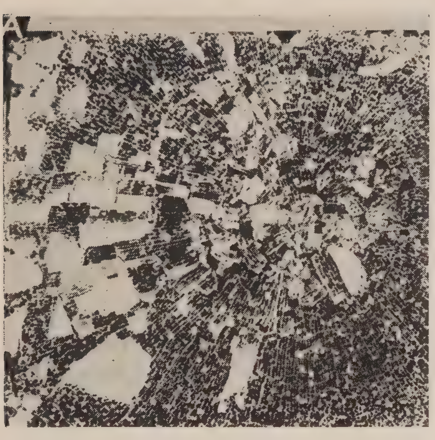
Fracture Test

This test is also applied to heat-treated glass, and is a continuation of the ten foot ball test with a view to determining the fracturing characteristics. The same specimens are used and the ball is dropped from increasing heights until the glass breaks.

A certain maximum weight is specified for the largest fragment of broken glass free from cracks. Fig. 3 (A) shows the result of fracture of a specimen of heat-treated glass.

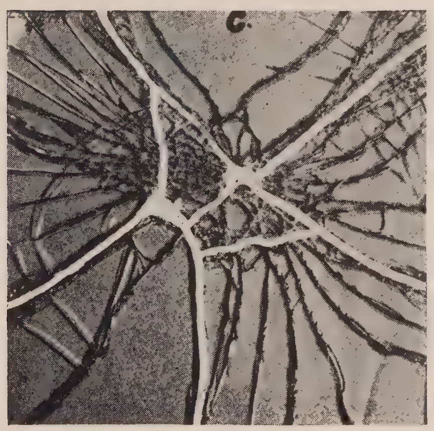
Shot Bag Test

The minimum strength of heat-

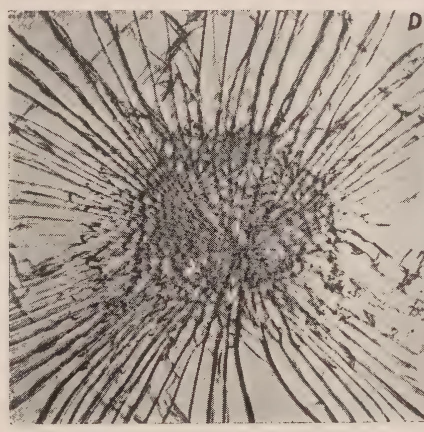


A

B



C



D

Fig. 3.

(A)—Typical fracture of heat-treated glass.

(B)—Typical fracture of laminated glass in the dart test.

(C)—Fracture resulting from a severe impact on laminated glass using an older type plastic. The sample has broken into several pieces.

(D)—Fracture resulting from the same severe impact as in (C) on laminated glass using a new type plastic.

treated glass under the impact of a large object is determined by this test. The glass is supported in the wooden frame and the shot bag, shown in Fig. 2, is dropped from a height of eight feet on the centre of the specimen. In order to conform to the requirements, the glass must not break or crack when subjected to this test.

Dart Test

The dart test is applied to laminated glass to determine the behaviour when struck by a small hard object. The dart, shown in Fig. 2, is dropped freely from a height of 10 feet to strike the specimen at the centre. The glass is judged by the amount of glass leaving the specimen and the locations from which it has become detached.

Fig. 3 (B) illustrates a fracture resulting from the dart test.

Ball Test (16-foot drop)

The object of the sixteen foot drop ball test is to determine whether laminated glass has been properly made and has a certain minimum strength. As this test is designed to show whether the glass approaches the most satisfactory combination of desirable properties the impact is made as severe as possible consistent, of course, with the strength, resistance to impact and adhesion of the glass and plastic.

A one half pound steel ball is dropped from a height of 16 feet striking the glass at the centre of the specimen. The glass is in a state of thermal equilibrium and supported in the usual wooden frame. The severe impact often breaks the specimens into separate, large pieces, but should this happen to more than two out of ten specimens of any one brand, it constitutes a failure. Another criterion in this test is the area of plastic exposed by the impact.

To illustrate the improvement in plastics in the last few years, two specimens of laminated safety glass, one using an older type plastic and the other a new type, were subjected to a severe impact test under exactly the same conditions. The result of the impact is shown in Fig. 3 (C) for the old type plastic and in 3 (D) for the new type. Note that the glass made with the old type plastic has broken into several pieces.

Visibility Distortion Test

In order that safety glass will be suitable for use in windshields, it must not seriously distort vision. The following test is used to determine the suitability of glass for windshield use.

A line is projected by a lantern on a screen. The glass specimen is moved across the beam at right angles to the direction of the projected line and at a distance of 25 feet from the screen. The degree of distortion caused by the glass will be indicated by the movement of the projected line as seen on the screen. The specification sets limits for the movement of this line and glass intended for windshield use must comply.

Conclusion

Safety glass which successfully withstands the foregoing test can be expected to give good service in motor vehicles when exposed to sunlight, moisture and high temperatures. The tests also indicate that the glass has a reasonably high resistance to fracture by impact and when broken is not likely to cause severe cuts.

Some of the tests in use at the present time give consistently negative results and it is probable that in future specifications they may be omitted. One such test is the boil

test. It may be advantageous, however, to add other tests such as a uniformity test for heat-treated glass by observation in a polariscope. It is also known that safety glass does not retain its desirable properties to the same degree at extremely low and high temperatures.

The Care of Poles

By T. H. Chisholm, Chemist, H.E.P.C. Laboratory

A TREE of sufficient size to make a first-class pole for power transmission is not of very great value. However, after it is cut down, trimmed, peeled and shipped to the pole yard, its value has increased several times, and when it is placed in the transmission line it becomes a rather valuable unit.

As it is often necessary to have a number of poles on hand at all times for replacement and new construction, care should be taken in the storage of these poles so that they will remain in a sound condition up to the time of erection.

For storing poles, a dry location, generally free from shade, should be selected. Having chosen a suitable site, the ground should be cleared of all chips, decayed wood and other vegetation. To prevent a new growth of grass or weeds the ground should be sprayed with creosote oil at intervals, or treated by some other suitable means.

The poles should be piled on suitable skids of a height such that the poles will be at least 1½ feet above the ground. The skids, if made of timber, should be sound and preferably pressure treated with creosote. If it is not convenient to pressure creosote the skids, they should be given a brush coat of creosote at intervals.

When poles are piled on the skids it is desirable to have them stacked loosely to allow free circulation of air through the piles. The space between the skids should be left open to permit free air circulation under the pile. It is important that the poles should shed as much water as possible during wet weather, and free circulation of air is necessary to permit evaporation of moisture from the poles in dry weather. This will help prevent the rapid growth of fungi with which all poles are infected.

Often when poles are to be stored for an extended period, the application of some protective coating is advisable. The coating used should be of a nature that will allow "breathing", i.e. the passage of air and water vapor through the surface. Creosote oil is satisfactory for this purpose. Our experience indicates that paint should not be used as the moisture which enters the pole through checks, spur cuts, etc., is trapped under the paint film. This condition contributes to rapid decay. See also extracts from

Current Publication and Trade Bulletin below.

Where new untreated poles are to be erected in more densely populated areas, the brightness of the new wood is sometimes objectionable until it reaches a weathered appearance; however, where it is desirable to darken the pole, creosote oil, which gives the surface a dark brown color, is the most satisfactory material. If a coating of a different color is desired, a good grade of shingle stain could be used or a tar free creosote mixed with a paste pigment (pigment ground in oil) in the ratio of two pounds of pigment per gallon of oil.

The Western Red Cedar Association states in their Bulletin number 31:

> "Experiences in many places throughout this country have shown conclusively that painting poles with a heavy oil paint contributes directly to sapwood decay. A heavy coat of high grade drying oil paint tends to seal the pole surface. Water gains entrance into sapwood through spur holes and other breaks in the paint and is greatly retarded in evaporation. This prevents the normal rapid drying of the sapwood and creates conditions that directly foster decay.
>
> "The dressing up of poles and pole lines is highly commendable, but the use of drying oil (such as linseed) paints is definitely discouraged. A good grade of wood stain, similar to that used on shingles, is recommended. It may carry the same color pigment as the paint, give the same appearance, last as long as necessary and does not seal the pole surface. It serves the same purpose, that of appearance, as paint; does not contribute to sapwood decay and is much less expensive."

The Bell Lumber and Pole Company, of Minneapolis, states on page 25 of its Technical Catalogue on Cedar Poles—

> "The use of paint of any kind for coloring poles when such coloring is required under City ordinances, is not recommended. Research has shown that such painting of poles is an important contributing factor to the setting up of conditions causing much earlier deterioration of sapwood than would otherwise prevail . . . ."
>
> "A good stain to use, one which does not seal the surface, but which allows free moisture evaporation from the sapwood, is a ground in oil paste and uncolored creosote oil, mixing approximately one pound of paste to one gallon of oil, preferably mixing in small quantities and putting on with a spray gun. Any color desired can be obtained . . . ."

Investigation of Artificial Ground Terminals

By the Grounding Committee, H.E.P.C. of Ontario

(Continued from May)

B. FROST

A comparison was then made between the actual temperature and rainfall for Toronto and vicinity during the period of test, and the normal as calculated by the Meteorological Office.

The temperature curves show that the winter of 1932-33 was particularly mild, having only two points below the normal. This condition was reflected in the depth of frost penetration. The winter of 1933-34 was particularly severe, having ten weeks of sub-normal temperature which forced the frost down to great depths. Discrepancies appear at Stations 1 and 2A where the frost penetration was about the same both winters. This is explained by the fact that both these locations were covered by a heavy blanket of snow during the coldest part of the latter winter.

In 1932 the first frost was observed on December 2nd and it had penetrated about the same depth, four or five inches, at all stations. However, the first frost the next winter, on December 15, 1933, penetrated to about 7 inches in the clay and loam but went to 13 inches in the sand and gravel. The same rapid penetration in light soil was noted after each very cold period. The same characteristic was noted with regard to the thawing of soil. In 1933 it required a week longer for the clay to thaw than the lighter soils; in 1934 it required three weeks longer in spite of the fact that the frost had penetrated 45 in. in sand and gravel as against 24 in. in clay.

Frost penetration and thaw were much more rapid in disturbed soil than in undisturbed soil.

The effect of frost on ground terminal resistance is quite apparent since in every case the maximum occurred during frost condition.

The effect is particularly interesting on shallow terminals. It was noted that as soon as the frost line approached the depth at which the terminals were installed the resistance increased from 200 to 3600 per cent. This percentage increase is apparently independent of the soil because it varied widely at all locations.

Comparing the 10 ft. mesh, 24 in. deep, with the 45 ft. copper strip at the same depth we have the following results. (See table at top of next page).

The 45 ft. strip only is mentioned as being comparable to the mesh and in every case is shown to be much superior; in fact the 15 ft. strip was, in some cases, better than the mesh.

A comparison of the two types of mats is not conclusive but in view of the superiority of strip as a shallow

Station Number	10 ft. Mesh		45 ft. Strip		Soil
	Max. Res.	Min. Res.	Max. Res.	Min. Res.	
1A	155	46	87	18.5	Loam—Rock at 6 ft.
2A	118	19.5	30	11.0	Clay
3A	2750	140	1100	58	Gravel
4A	2750	115	800	50	Sand

terminal the mesh may be disregarded. However, the results are as follows:

Station Number	Soil	Mat		Max. Resistance	Min. Resistance
		Size	Depth		
1	Loam—Rock 3-5 ft.	20 ft. by 3 ft.	10 in.	175	14.7
1A	Loam—Rock at 6 ft.	10 ft. by 3 ft.	24 in.	155	46
2	Clay	20 ft. by 3 ft.	10 in.	400	17
2A	Clay	10 ft. by 3 ft.	24 in.	118	19.5
3	Gravel	20 ft. by 3 ft.	10 in.	1350	78
3A	Gravel	10 ft. by 3 ft.	24 in.	2750	140
4	Sand	20 ft. by 3 ft.	10 in.	1500	100
4A	Sand	10 ft. by 3 ft.	24 in.	2750	115

It is evident from examination of the data observed on *deep terminals* that there is a definite effect from frost beyond that which may be attributed to the insulating by frozen earth of the upper part of a rod extending to the frost line.

It appears reasonable to suppose that on account of the thermal conductivity of the rod the resistance of the rod below the frost line is also affected seriously and this may be caused (1) by a depression of the frost line immediately surrounding the rod or (2) it may be caused by the prevention of percolation of water into the earth by the frozen surface soil or (3) it may be caused by both of these conditions.

A comparison of treated and untreated 10 ft. steel rods would indi-

Station Number	Term Number	Size of Terminal	Max. Res.	Min. Res.
3	C	10 ft. by ½ in.	1600	400
3	B	10 ft. by ¾ in.	1100	270
4	A	17½ ft. by ½ in.	1400	340
4	B	20 ft. by ⅝ in.	775	390
4	C	21 ft. by ¾ in.	650	230
3	A	21 ft. by ⅝ in.	75	46
3	D	21 ft. by ¾ in.	53	31

cate that, apart from the lower resistance of the former, there is little to choose between the all-season characteristics of the two types. On the average the frost apparently affects them about equally.

those caused by the severe frost condition during the winter of 1933-34.

The meagre snowfall during the past winter was a major factor in the unprecedented frost penetration. The exceptions are station No. 1 which is

Station Number	10 ft. Rod Plain		10 ft. Rod S.T. Basin		10 ft. Rod S.T. Tile	
	Max.	Min.	Max.	Min.	Max.	Min.
1	70	41	45	11.5	80	15.3
1A	230	57	52	18.1	60	18.0
2	71	29	20.2	10.1	16	9.5
2A	50	26	15.4	9.9	15.5	9.8
3	900	200	710	40	900	60
3A	3000	330	480	78	710	100
4	1750	400	400	75	510	92
4A	450	120	170	5	540	110

Although frozen soil is a poor conductor at any time the conductivity is considerably decreased as the temperature drops further below 32 deg. fahr.

C. Precipitation

The curve comparing the actual precipitation for the test period with the normal reveals the fact that the actual was considerably below the normal, except in the fall of 1932. The summer of 1933 was particularly dry with an average monthly rainfall of about 1.75 in. as against the normal of approximately 3 in. per month. Snowfall was much below average both winters but more so during 1933-34.

All these variations are clearly reflected in the resistance curves. Many of the minimum values were reached during August and November, 1932, on account of the copious rainfall. The summer of 1933 produced a drought condition which increased resistances to values second only to

in a sheltered location protected from direct sun, and station 2A on which the snow drifted to a depth of 3 to 4 feet and remained all winter.

The effect of spring moisture, i.e., melting snow, produces a very marked decrease in resistance but since it occurs at the same time as the thawing of the soil it is hard to separate the effects. However, it will be noticed that the resistance continues to drop after the frost is all out and this latter decrease is the direct result of the excess moisture. This continued downward trend obtains for two or three weeks and is slightly longer in heavy soil than in sand or gravel.

The effect of a heavy rainfall is almost immediately apparent in light soil, and particularly on shallow terminals. The effect is not quite so marked in clay but is more lasting.

This variation from week to week, or even day to day, is apt to be confusing, particularly during the critical periods in spring and fall.

D. Soils

The four soils chosen for this test show in the observed values variations through the seasons which are quite different for each. It should be noted that stations No. 1 and 1A, shallow soil over rock, are perhaps not truly typical of this soil condition in that they were both located in the Humber valley near the river bank and sheltered in the summer from direct sun and in the winter accumulated a good snow cover. The other locations were in open country and should be quite typical.

Shallow Soil Over Rock

This condition obviously makes the use of long rods impossible unless driven at an angle to the vertical. However, the main difference between the slanted rod and the horizontally placed shallow terminal is that the driven rod will always have its lower portion close to the rock where moisture may be expected, and will be in undisturbed soil. The results of this test show that the copper strip 45 feet long has a greater range of fluctuations than the 10 foot rod driven to the rock in a slanted position, the high values being the same and the low in favor of the strip. The curves show the strip more seriously affected by frost and drought.

Clay

The results show clay to be the most consistent of all soils in its performance through the seasons. Being one of the more dense soils all the changes are accomplished at a slower rate. Frost penetrates more slowly than in gravel or sand and thawing is more gradual. Moisture percolates more slowly and takes longer to dissipate.

The range of the resistances of all terminals is smallest in clay.

Gravel and Sand

Both gravel and sand are loose, porous soils and behave with marked similarity. Since both have large proportions of high resistance materials such as silica, slate, etc., in their composition, such similarity might properly be expected.

Frost penetration in sand and gravel is very rapid and also very deep as compared to clay. Thawing is also much faster in the light soils, and moisture soaks away quickly.

These conditions produce a great range of resistance values, generally high, for all terminals and particularly the shallow ones. Since light soil does not retain moisture very well such land is particularly affected by drought. So far as ground resistance is concerned drought is almost as bad as frost condition for the shallow terminals.

E. Soil Treatment

Four types of salt-treated terminals were experimented with, namely basin, tile, copper tube, and 8 ft. by 1 in. perforated pipe. The two latter were based on the same principle of pouring brine down inside the terminal and having it seep out the holes and into the soil immediately around the pipe. (See table at top of next page.)

The above table shows quite definitely that the basin type gives a lower resistance all year round than the tile type, and this is most pronounced in sand and gravel. The difference is accounted for by the small-

Station Number	10 ft. by ¾ in. Steel Rod				8 ft. by 1 in. Perf. Pipe		6 ft. by ⅝ in. Copper Tube	
	Basin Type		Tile Type					
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	45	11.5	80	15.3	195	33	—	—
1A	52	18	60	18	105	32	NaCl 100	32
2	20.2	10	16	9.5	45	19	NaCl 62	24
2A	15.4	9.9	15.5	9.8	27	14.8	$CuSO_4$ 69	32
3	710	40	900	60	1300	210	NaCl 1500	145
3A	480	78	710	100	770	108	$CuSO_4$ 2550	280
4	400	75	510	92	1020	155	$CuSO_4$ 1400	290
4A	170	50	540	110	1400	200	NaCl 1800	175

er capacity of the tile and because the top 2 ft. of rod is insulated by the tile.

These tests indicate the order of preference to be:—

1. Basin Type.
2. Tile Type.
3. 8 ft. by 1 in. Perforated Pipe.
4. 6 ft. by 5/8 in. Copper Tube.

The experiment with two types of salt solutions on the copper tubes shows that the NaCl solution is superior to $CuSO_4$ solution.

The basin and tile at stations 1, 2, 3 and 4 were subjected to accelerated action by pouring a pail of water on each, every week till October 28, 1932.

The accelerated action apparently used up all the salt in four to six months, at the end of which time the resistance began steadily to increase. The corresponding terminals without acceleration were only slightly higher in May, 1934, than during their lowest period in November, 1932. This would indicate that the life of salt treatment in sand and gravel is somewhat over two years, with a steady downward trend for about four months after installation.

Salt treated terminals in clay have shown no upward trend in two years.

F. Special Terminals

At stations 1 and 1A there was approximately 4 ft. and 6 ft. of soil respectively and the rods were driven on the slant. At the former the all-season characteristics were similar to those for rods driven straight down to depths of 6 ft., 8 ft. and 10 ft. in similar soil, but were much better than expected. This was due to the marshy nature of the soil, there being a layer of water-soaked earth next to the rock. At station 1A the resistance of the slanted rods was very erratic. This was likely caused by the good drainage through the light soil and along the rock.

The T-shaped rods which were installed at several stations were found to have characteristics almost identical to the ¾ in. round rods of similar length.

The spear head type terminals were found to be excessivly high in resistance and quite erratic in performance, probably because the disturbed soil was not making positive contact with the copper lead wire.

At station No. 2A a ¾ in. star-shaped solid copper rod was driven. Its original length was 10 feet but it was too soft to drive full depth in the clay and was cut off 3 feet from the top. The minimum resistance compared favorably with the 6 ft. and 8 ft. steel rod but the percentage variation in frost was considerably greater. This was probably due to the better heat conducting properties of copper which would depress the frost line immediately around the terminal. The extra area of contact was evidently unimportant.

CONCLUSIONS

The matter herein might better be classed as "observations". Some of the statements made here are necessarily a confirmation of conclusions which are already generally accepted. This by no means detracts from their value.

In studying the performance of the various terminals in the different classes of soil, it will be essential to keep in mind that the classes of soil chosen at the test stations are typical, but that in actual practice innumerable variations will be found. Particularly it must be kept in mind that where a high resistance soil overlies a low resistance soil, the depth of the former will vary greatly at different locations.

It is generally recognized that the value of a terminal, such as a driven rod, increases with its length. It should be understood that the improvement is due principally to the fact that the longer rod contacts usually with a lower resistance soil having a greater and more constant moisture content. At some depth, which is not the same for all soils and conditions, the rod will have reached a location which is practically unaffected by temperature, precipitation, etc., through the changing seasons.

The fact that a lowered resistance may be obtained by installing terminals in parallel is also well known.

The practical application of the above facts, i.e., improvement by greater depth and improvement by adding terminals in parallel, must be made with careful consideration to obtain the desired result. While each location might be investigated to determine the cheapest method of lowering the resistance, in practice this is evidently impractical. Therefore a standard terminal must be chosen, which without being too expensive will be satisfactory for a large percentage of the installations to be made.

In general it may be stated, and exceptions will frequently be found, that greater length of rod will be more effective than the addition of rods in parallel; also that for economy the length of rod will be limited only by the difficulty experienced in driving.

The value of a terminal wholly surrounded by frozen soil is practically nil and frost may reach a depth in excess of 4 ft.

Frost penetration is much more rapid and the penetration is deeper in

light soils than in heavy soils. Thawing is also accelerated in light soils.

A blanket of snow greatly reduces the frost penetration.

In general the minimum resistances are found to occur in the spring just after the frost leaves the ground.

Soil treatment is definitely valuable in all soils, but the lasting effect of an application is much more pronounced in dense soils than loose soils. In sandy soils where the need of treatment is greatest more frequent renewal of the treatment is required than in clay.

The beneficial result of salt treatment in clay soil is remarkable and it may therefore be economical to salt treat single rods in preference to installing extra rods.

The "basin type" of salt treatment appears to be better than the "tile type". Both of these show a steady downward trend of resistance for about four months and an effective life of more than two years in light soils and probably very much longer in dense soils.

Treated terminals, as compared to untreated, show improved results throughout all seasons, and the percentage variations of resistance through the seasons is approximately the same for treated and untreated terminals.

Common coarse salt was found to be a better material for soil treatment than copper sulphate and 100 lb. would appear to be a suitable quantity to treat one rod.

In some soils and under some conditions drought may affect the resistance to as great an extent as frost.

In the case of driven rods, unless the rod has penetrated to permanent moisture, the resistance will vary noticeably from week to week, being dependent for its efficiency on the supply of moisture percolating through from the surface, and as would be expected the variation is more pronounced in light than in heavy soils.

Where shallow terminals are used, the strip appears to be superior to the mesh for comparable installation costs, but the general use of shallow terminals will undoubtedly be limited to conditions where deep terminals are impractical.

In analyzing the data obtained it is well to bear in mind the fact that the maximum values often appear as sharp peaks, particularly with shallow terminals. This maximum value may obtain for only a few days during the year and in some cases it may be unfair to condemn a terminal on such evidence. More accurate observations may be obtained by studying the curves themselves and striking averages for the maximum and minimum resistances.

Referring to Section 1 of this report entitled "Object of Investigation", we would make the following comments:

(a) The 10 ft. by ¾ in. steel rod would appear to have the best practical all-season characteristics for use as an artificial ground terminal in Ontario. Any change from this selection should tend toward a longer rod, particularly in light soils.

(b) and (c) The extent of seasonal variation of resistance and the effect of frost penetration on the various types of ground terminals is shown

completely on the accompanying curve sheets.

(d) The effect of precipitation on artificial grounds is also covered in the curve sheets. The information obtained shows that, with the exception of frost, precipitation is the most important single factor affecting the range of ground resistances. Heavy precipitation, i.e., snowfall, will minimize frost penetration. If precipitation in the summer, i.e., rainfall, is below normal the effect is immediately seen in the increase in ground resistances. This latter condition may produce seriously high values in the event of a drought.

(e) Shallow terminals are, generally speaking, unsuitable for use in Ontario soils because of the severe frost conditions met with. If, in the case of rock close to the surface, a shallow terminal must be used, strip is more effective than mesh.

(f) Soil treatment is definitely valuable in reducing ground resistances in all classes of Ontario soils. Due to the comparatively long life of treatment in dense soils it may be found economical to salt treat single rods in such soils in preference to installing extra rods.

The basin type of soil treatment is more effective than either the tile type or the perforated pipe and NaCl appears to be a better material for soil treatment than $CuSO_4$.

Previous articles on Grounding, in the Bulletin and elsewhere, include the following:—

"Grounding", by E. M. Wood, Bulletin for July, 1927.

"Ground Connections for Electrical Distribution Systems", by A. G. Lang, Bulletin, February, 1932.

"Grounds", by Wills Maclachlan, Bulletin, August, 1933.

Bureau of Standards Technological Paper No. 108, 1918.

"Calculation of Resistances to Ground", by H. B. Dwight, Electrical Engineering, December, 1936.

The members of the Grounding Committee at the time of this Investigation were: Messrs. W. Maclachlan, chairman, A. S. L. Barnes, secretary, W. L. Amos, W. Baxter, W. B. Buchanan, W. P. Dobson, A. G. Hall, E. F. Hinch, A. G. Lang, E. R. Lawler, M. P. Osburn, J. D. Pace, of the Hydro-Electric Power Commission of Ontario and C. E. Schwenger of the Toronto Hydro Electric System.

The Selection and Application of Electric Motor Equipment

By R. McGeoch, Canadian General Electric Company, Limited, Toronto

AT this time when the majority of industrial plants are increasing production and considering methods of reducing costs and improving the efficiency of the plant, it is important that plant surveys be made to check correct motor applications. The time spent invariably returns substantial dividends and improves plant operation.

The choice of any particular type of motor is dependent on one or more factors identified with each particular application. These factors or conditions will be discussed under their respective headings.

Available Power

We will assume that the power available is 3 phase either 25 or 60 cycle, and 220, 440 or 550 volts, as single phase power for industrial use is both expensive and not satisfactory owing to the limitations it places on the electrical equipment. There is no question that wherever possible an engineer laying out a new plant addition should insist on a 3 phase power, even if the original cost of the transformers and distribution equipment is higher than the equivalent service for a single phase system. Direct current is not widely used as the cost of power and equipment is higher than for an a.c. system.

From an address to the Niagara Peninsula Electrical Maintenance Club at St. Catharines on January 19th, 1940.

Surrounding Conditions

When considering surrounding conditions, one has to analyze whether standard protected-type motors will be satisfactory or whether you should go to some of the slightly more expensive but better protected motors, such as splashproof for the dairy industry or totally-enclosed or enclosed fan-cooled, or enclosed pipe-ventilated for particularly dirty applications as found in flour mills, foundries, etc. Under certain conditions the motor manufacturer may want to offer special motors and the following is a list of applications that should be checked, as it is very seldom standard protected motors will suit any of the following conditions:

(1) Inflammable gases or dust where a spark would cause an explosion.

(2) Room filled with hot vapors.

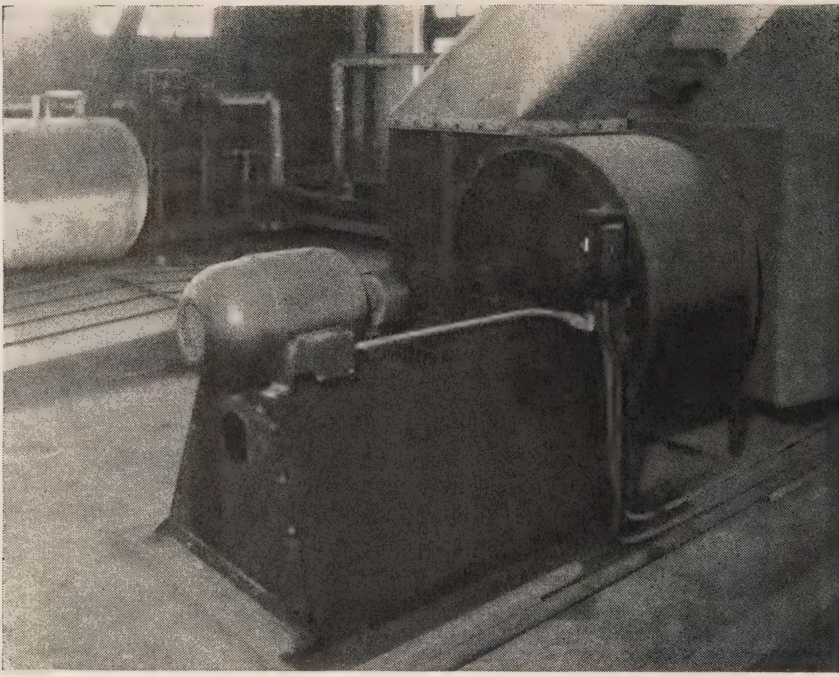
(3) Where strong acid or alkaline vapors are encountered.

(4) Excessive moisture.

(5) Room temperature more than 40 deg. cent., (104 deg. fahr.) or below zero cent. (32 deg. fahr.).

(6) Where windings are exposed to excessive amounts of conducting dusts, such as iron, carbon, coke, etc.

(7) Where windings are exposed to excessive amounts of abrasive



A totally-enclosed 3 h.p. fan cooled induction motor driving a centrifugal fan in a manufacturing plant.

dusts, such as stone dust, cement, etc.

(8) Occasional or repeated submersions, as on the deck of a ship.

(9) Excessive vibration.

(10) Where exceptionally quiet operation is required, such as in schools, churches and some types of commercial office buildings. This would include the majority of air conditioning applications.

Starting Conditions

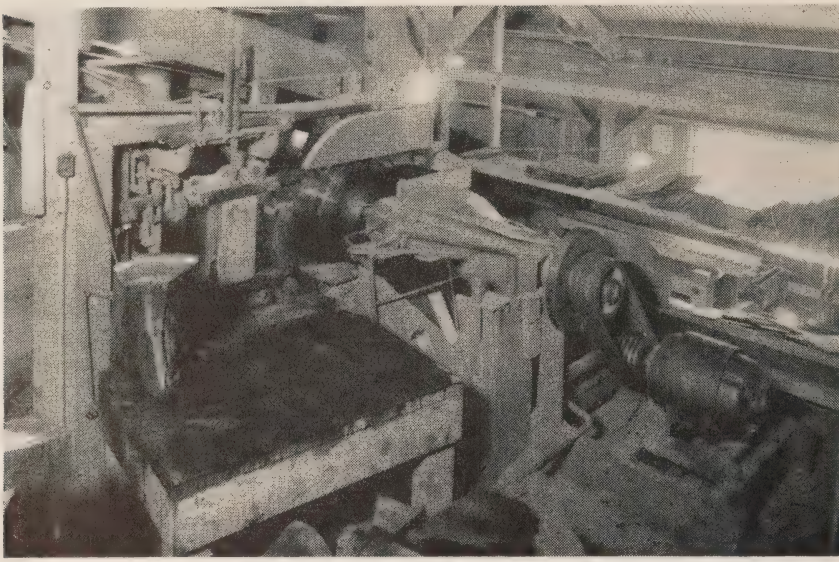
Certain problems arise as to the time the load takes to come up to speed and the frequency of starting and stopping, but in the majority of cases the purchaser knows from past experience both the type and rating of motor he requires, or if in doubt the manufacturer of the machine to be driven will supply the desired information.

It is very important to check the starting conditions. As an example, a 10 h.p. motor on a refrigeration compressor or an air compressor installed without an unloader, the unit usually stops on the compression stroke, and a standard squirrel cage motor does not have sufficient starting torque to start the unit. In this case the motor manufacturer will insist on supplying a high torque motor at a slightly higher price, if he is told the application. Another example is

PRINCIPAL TYPES OF STANDARD GENERAL-PURPOSE CONSTANT SPEED MOTOR

Industrial power motors, not designed and listed for specific power application (where the load requirements and duty cycle are definitely known), are termed general-purpose motors. In sizes, they are confined to those motors of 200 h.p. or less and 450 rev. per min. or more, having a continuous-time rating on a temperature rise basis of 40 deg. cent.

Type of Motor	Starting Duty	Speed	Max. Torque Per Cent Full Load	Suggested Control	Remarks
Single-phase, Split phase	Medium	Constant, close regulation	250 (Approx.)	Full-voltage hand starting Full-voltage magnetic starting	Suitable for domestic and industrial use on appliances and small machines.
Single-phase, High torque capacitor	Heavy	Constant, close regulation	240 (Approx.)	Full-voltage hand starting Full-voltage magnetic starting	Suitable for domestic and industrial use on appliances and small machines.
Single-phase, Repulsion Induction	Heavy	Constant, close regulation	165 to 200	Full-voltage hand starting Full-voltage magnetic starting Reduced-voltage starting	Will accelerate practically any load it can start.
Polyphase, Normal-torque, Normal-starting-current Squirrel-cage	Medium	Constant, close regulation	175 to 250	¼-5 h.p. { Hand control, Magnetic 7½-200 h.p { Hand compensator, Automatic starting compensator, Automatic primary resistor, Magnetic	The simplest and most widely used motors made.
Polyphase, Normal-torque, Low-starting-current, Squirrel-cage	Medium	Constant, close regulation	200 (Approx.)	Magnetic switch	Full-voltage start; with starting current generally acceptable to power companies. Gives slightly higher torque, but approximately the same starting current as Type K on 80% compensator tap.
Direct-current, Shunt-wound	Medium	Constant, close regulation	Limited by commutation	Hand-starting rheostat or magnetic	25 per cent increase in speed by field control can be obtained on shunt-wound motors.
Synchronous	Medium	Constant	150 to 250	Refer to motor manufacturer for specific recommendations	Synchronous motors may be applied (1) where maximum power-factor and operating efficiency are desired; (2) where close speed regulation is demanded; (3) where motor speeds less than 500 r.p.m. are desired.



One of six 20 h.p. 1800 rev. per min., 440 volt, 3 phase, 60 cycle, protected type induction motors driving a shingle machine in a shingle mill.

where a standard squirrel cage motor is starting a very heavy fan load which often takes 30 to 40 seconds to come up to speed. In this case the motor will usually stand up, but the overload relay heater units on the control will trip out owing to the very long accelerating time of the load, and special overload relays have to be supplied.

Running Conditions

Under running conditions you can consider such factors as operating conditions, constant vs. adjustable speed, speed regulation and load conditions. It is usually desirable to pick as high a standard normal speed motor as good engineering practice will allow, although in the case of 25-cycle equipment this is not as important as in the majority of standard ratings—the 750 rev. per min. constant speed motor and the 1500 rev. per min. constant speed motor sell at about the same price level, while in the case of 60-cycle motors the 1800 rev. per min. motor has the lowest first cost and the lower the speed the higher the price. This, of course, does not mean that where you can direct couple the motor to the load, it would be recommended that a high speed motor be used and either a V-belt or some other means used of reducing the speed to the driven machine. In cases such as this, one has to use good judgment and check the cost of the motor against the cost of the speed reducing gear, keeping in mind that there is a certain amount of maintenance on either belting or gearing, which you do not have in the slow speed, direct coupled motor. Another factor to be considered is that low

speed induction motors have a lower power factor than high speed motors.

In connection with constant vs. adjustable speed, it is desirable for the majority of applications to use constant speed motors if at all practical. Adjustable speed motors are more expensive and unless the quantity or the quality of the output of the machine would be improved, it pays to use constant speed motors.

Regarding speed regulation, close speed regulation from no load to full load is desirable for machine tools, textile machinery, line shaft drive, and similar work. Wide speed regulation is desirable with flywheel type loads, such as punch presses, where the work strokes occur less than twenty-five times per minute, or where peak loads occur which might greatly overload the motor if it did not automatically slow down to take care of this condition. Motors of the slip ring or wound rotor type, or direct-current motors with armature control give adjustable varying speed with close speed regulation if the torque required by the driven machine is constant, and wide speed regulation if the torque required is fluctuating.

Load Conditions

All standard, general-purpose motors are designed to carry reasonably fluctuating loads, both below and above normal rating, and the equivalent average load determines the size of the motor. Under certain conditions the starting rather than the running duty cycle determines the size of the motor selection, and in other cases the peak loads become the determining factor.

The Driven Machine

The arrangement of the driven machine will usually determine whether a horizontal or vertical motor is needed. The horizontal motor is usually used and in general is less expensive than a vertical motor, although the modern ball bearing, grease-lubricated motor of to-day can be used in a vertical position with shaft up or down. Any standard NEMA ball bearing motors can be used for inverted operation or side wall mounting, in any position without any change. Direct connection should always be used where the required speed coincides with the available motor speed. Here again, one must carefully analyze the question of cost against the type of drive when the speeds are low.

In the case of belt drive, either flat belt or V-belt, the diameters and widths of pulley and the centre distance between the driving and the driven pulley are factors in determining the motor bearing pressures and shaft deflections.

Individual vs. Group Drive

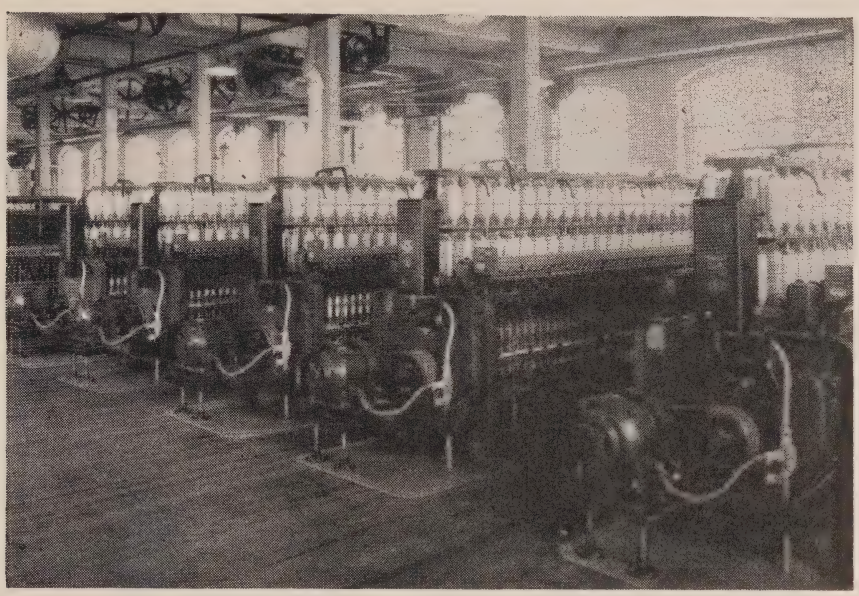
This has always been a rather contentious point and no hard-and-fast rule can be laid down for every application. The particular factors involved must be analyzed and judgment used in coming to a decision as to whether individual or group drive should be adopted. As an example, there is usually a money saving in operating expense with individual drive which has to be weighed against the probable saving in initial cost with group drive. There is no doubt that a considerable saving in initial

PRINCIPAL TYPES OF SPECIAL-SERVICE AND HEAVY-STARTING-DUTY MOTORS

Motors in This Tabulation Are Used Only When General Purpose Are Not Suitable

Type of Motor	Starting Duty	Speed	Max. Torque Per Cent Full Load	Suggested Control	Remarks
Polyphase, Wound-rotor	Heavy, Governed by type of control furnished	Constant or adjustable-varying, depending upon type of control used	175-250	*Constant-speed* ½ to 15 h.p. Hand starting† {Primary switch; Secondary rheostat} Above 15 h.p. Hand starting† {Primary switch; Secondary drum switch with resistor} †Remote-control starter *Adjustable-varying-speed* ¾ to 15 h.p. {Primary switch; Secondary rheostat} Above 15 h.p., Hand control {Primary switch; Secondary drum switch with resistor}	Used with proper type of control where frequent and heavy starting is required, or where low starting current is imperative, or where adjustable-varying speed is desired.
Polyphase, High-torque, Low-starting-current, Squirrel-cage	Heavy, but at not too frequent intervals	Constant, close regulation	200	†Remote control, full-voltage starting—magnetic switch Hand-starting compensator	No centrifugal devices. High torque per ampere at start. Control simplified. Especially applicable to pumps and compressors, and other similar machines.
Polyphase, High-slip, Squirrel-cage	Heavy, but at not too frequent intervals	Constant, wide regulation	300-400	†Remote control, full-voltage starting—magnetic switch	Especially desirable for use with flywheels to care for high-peak loads that occur less than 25 times a minute.
D-c Motors Shunt-wound	Medium	Constant, close regulation	Limited by commutation	Remote control {Magnetic with field rheostat and start-stop push button}	25 per cent increase in speed by field control can be obtained on shunt-wound motors.
D-c Motors Compound-wound	Heavy	Constant, 25% speed regulation	Limited by commutation	Remote control {Field rheostat; Start-stop push button}	For flywheel loads and other widely fluctuating loads that occur less than 25 times a minute.
D-c Motors Series-wound Mill Type	Very heavy	Wide speed regulation; must be geared to load	Limited by commutation	Refer to motor manufacturer for specific recommendations	For hoist and similar service.
D-c Motors Shunt-wound Adjustable-speed	Medium	Adjustable, close regulation	Limited by commutation	Hand control—drum switch with resistors Remote control {Nonreversing with field rheostat; Reversing, with field rheostat and start-stop push button}	For machine-tool and other work requiring adjustable speeds.

Gear-motors are available in any of the electrical types listed when output-shaft speeds of 600 rev. per min. or less are desired.
†Provides overload and undervoltage protection.



Seven and one-quarter horsepower screenless open textile motors driving spinning frames in a textile plant.

cost of the motor equipment can be made with group drive. In general, this saving in first cost will be realized where there are compact groups of constant speed machines which will be required to run continuously or simultaneously. Also with compact groups of machines, which because of their diversity factor in operation, may be driven by a single motor of much smaller rating than the combined capacity of the motors required for individual drive.

In a case such as this it is seldom that all machines in a group will be fully loaded at the same time and a motor capable of carrying the average load of the group may, therefore, be selected; its overload capacity being sufficient to take care of any short time overload conditions.

Group drive is also desirable where heavy peak load demands might require individual motors of a size considerably in excess of the average running load. Another case would be when the motors required for individual drive are small and also where you are changing over an existing plant where the line shafting is already installed and in good condition. The following conditions are usually favorable to individual drive:

1. Where the machines are isolated, requiring long lines of shafting to combine with other groups, so that the cost of the transmission more than offsets the extra expense of individual motors.
2. Where the roof construction will not safely support line shafting, or where the additional expense of making it sufficiently strong would be excessive.

OPERATION ON SLIGHTLY OFF-STANDARD VOLTAGES AND FREQUENCIES

GENERAL-PURPOSE MOTORS

GENERAL EFFECT OF VOLTAGE AND FREQUENCY VARIATION ON INDUCTION-MOTOR CHARACTERISTICS

● = Increase ▲ = Decrease

		Starting and Maximum Running Torque	Synchronous Speed	% slip	Full-load Speed	EFFICIENCY Full Load	EFFICIENCY ¾ Load	EFFICIENCY ½ Load	POWER-FACTOR Full Load	POWER-FACTOR ¾ Load	POWER-FACTOR ½ Load	Full-load Current	Starting Current	Temperature Rise, Full Load	Maximum Overload Capacity	Magnetic Noise, No Load in Particular
Voltage Variation	120% Voltage	●44%	No change	▲30%	● 1.5%	Small ●	▲ ½-2 points	▲ 7-20 points	▲ 5-15 points	▲ 10-30 points	▲ 15-40 points	▲11%	●25%	▲ 5-6° C	●44%	Noticeable ●
	110% Voltage	●21%	No change	▲17%	●1%	● ½-1 point	Practically no change	▲ 1-2 points	▲ 3 points	▲ 4 points	▲ 5-6 points	▲7%	● 10-12%	▲ 3-4° C	●21%	Slight ●
	Function of Voltage	$(\text{Voltage})^2$	Constant	$\frac{1}{(\text{Voltage})^2}$	(Syn speed slip)	—	—	—	—	—	—	—	Voltage	—	$(\text{Voltage})^2$	—
	90% Voltage	▲19%	No change	●23%	▲ 1½%	▲ 2 points	Practically no change	● 1-2 points	● 1 point	● 2-3 points	● 4-5 points	●11%	▲ 10-12%	● 6-7° C	▲19%	Slight ▲
Frequency Variation	105% Frequency	▲10%	●5%	Practically no change	● 5%	Slight ●	Slight ●	Slight ●	Slight ●	Slight ●	Slight ●	Slight ▲	▲ 5-6%	Slight ▲	Slight ▲	Slight ▲
	Function of Frequency	$\frac{1}{(\text{Frequen.})^2}$	Frequency		(Syn speed slip)	—	—	—	—	—	—	—	$\frac{1}{\text{Frequency}}$	—	—	—
	95% Frequency	●11%	▲5%	Practically no change	▲ 5%	Slight ▲	Slight ▲	Slight ▲	Slight ▲	Slight ▲	Slight ▲	Slight ●	● 5-6%	Slight ●	Slight ●	Slight ●

NOTE:—This table shows general effects, which will vary somewhat for specific ratings.

GENERAL EFFECT OF VOLTAGE VARIATION ON DIRECT-CURRENT CHARACTERISTICS

● = Increase ▲ = Decrease

Voltage Variation	Starting and Max. Run Torque	Full-load Speed	Efficiency: Full Load	Efficiency: ¾ Load	Efficiency: ½ Load	Full-load Current	Temperature Rise, Full Load	Maximum Overload Capacity	Magnetic Noise
SHUNT-WOUND									
120% Voltage	●30%	110%	Slight ●	No change	Slight ▲	▲17%	Main field ●. Commutator field and armature ▲.	●30%	Slight ●
110% Voltage	●15%	105%	Slight ●	No change	Slight ▲	▲8.5%	Main field ●. Commutator field and armature ▲.	●15%	Slight ●
90% Voltage	▲16%	95%	Slight ▲	No change	Slight ●	●11.5%	Main field ▲. Commutator field and armature ●.	▲16%	Slight ▲
COMPOUND-WOUND									
120% Voltage	●30%	112%	Slight ●	No change	Slight ▲	▲17%	Main field ●. Commutator field and armature ▲.	●30%	Slight ●
110% Voltage	●15%	106%	Slight ●	No change	Slight ▲	▲8.5%	Main field ●. Commutator field and armature ▲.	●15%	Slight ●
90% Voltage	▲16%	94%	Slight ▲	No change	Slight ●	●11.5%	Main field ▲. Commutator field and armature ●.	▲16%	Slight ▲

NOTES:—Starting current is controlled by starting resistor.
This table shows general effects, which will vary somewhat for specific ratings.

OPERATING COSTS GROUP VS. INDIVIDUAL DRIVE

Unless carefully maintained the transmission equipment such as line shaft and belting, etc., will decrease in efficiency on account of gradual misalignment of shafting, increased belt slippage, etc. These losses may be partly offset by the fact that the efficiency of a larger motor for group drive is better than that of the smaller size of individual motors. Another point that must be considered today with power factor penalty clauses in effect, is that the power factor of large motors is higher than smaller motors and it is usually possible, because of the diversity factor of the driven machines, to use a smaller motor for group drive than the total combined horsepowers of the motors used on individual drive. This means better power factor for group drive and lower power costs.

Under certain conditions the reverse is the case as it might happen where a number of machines in the group are operated very intermittently or at infrequent intervals. Also where a certain amount of overtime or night work is necessary on certain machines which, with individual drive, could be operated economically, while in the case of group drive it might be necessary to operate a large motor to run one or two machines with an increase in power costs for the overtime period.

So far we have been discussing the pros and cons of individual vs. group drive in relation to the dollar value, but there are several other angles which have to be considered, such as production, working conditions, quali-

ty of the product, etc. These are very hard to translate into dollars, but over the years is very important to the owner of the plant. There is no doubt that individual drive gives the operator of the machine more complete control, and in the case of break-down the loss of production time is less, as production may be temporarily diverted to other machines, while with group drive the whole group may be affected. Other cases in point would be the use of portable tools where it is much easier to take a drill to the work than it is to bring the work to the drill.

There is no doubt that individual drive makes for a much cleaner and better lighted shop with no danger from belts or pulleys. Also with individual drive the control button can be located on the machine close to the operator; this feature tends to increase production and adds to the operator's safety.

Miscellaneous Conditions

Under certain conditions the use of group drive is almost automatically ruled out by the construction of the building or the nature of the work, such as plants where fairly heavy machinery is used, requiring clear overhead space for travelling cranes. The convenience and often the necessity of this moving material will offset any advantages group drive may otherwise have had.

Where machines are installed under galleries where there is not sufficient overhead for line shafting.

Where automatic or remote control of a machine is desired, such as control from a pressure tank, sump pump, or thermostat.

In certain plants periodic tests are made on each machine to determine the amount of power being used. With individual drive and jack type switches these tests may be made without stopping the machine, while with group drive a shut-down of all machines in the group would be necessary before completing the tests.

Summary

In summarizing the various advantages and disadvantages of group vs. individual drive we would repeat that any compact group of machines which may be equipped with a motor of considerably smaller capacity than the combined capacity of the motors required for individual drive, should be considered for group drive. Any machine operating at a fairly constant load not much below its maximum should be equipped with individual drive.

The cost of maintenance will be little different as between the two methods. Whatever is saved on motor maintenance with group drive because of fewer and possibly more accessible motors is likely to be used up in maintaining and inspecting line shaft bearings, belts, pulleys, etc.

The question of production is far more important and any means whereby production can be increased by speeding up the process, saving the workmen's time, locating machines for approved sequence of operation, or making handling of the material easier will affect and overrule other factors which on the surface may appear more important.—*Electrical Digest.*

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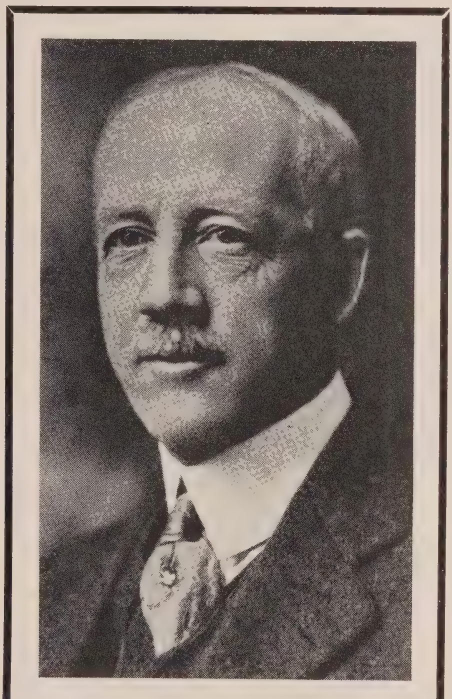

T. J. Hannigan

THOMAS J. HANNIGAN, secretary-treasurer of the Ontario Municipal Electric Association, passed away at his home in Guelph on Thursday, June 27th, 1940, aged 71 years.

He was born in Campbellford from which place he came to Guelph in 1888. As a citizen of Guelph he was always keenly interested in local affairs of the city, serving for a time as Alderman, and continually taking

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Vol. XXVII No. 7
July, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

deep interest in the work of the Board of Trade and Chamber of Commerce.

From the beginning of the Hydro movement in Ontario, he took an active part in the work. In this he was closely associated with the late Sir Adam Beck in carrying on campaigns throughout the province. As a result of this work he was in close contact with all of the men who were responsible for the formation and growth of the Hydro system, and was, therefore, an authority on its historical phases. He had a devout admiration for all the pioneers in the Hydro movement and would never tire in reminiscing on his associations with them.

After Hydro got well under way he became secretary-treasurer of the Ontario Municipal Electric Association, an organization composed of commissioners of Hydro utilities in the province. As such he has served faithfully for more than a quarter of a century. In 1929 he was instrumental in forming the Municipal Hydro Electric Pension and Insurance Plan, and has served as secretary of the committee in charge of it for a number of years.

Mr. Hannigan was a keen horticulturist and flower-lover and did much to further the work of the Ontario Horticultural Association, of which he was a past president, and the Guelph Horticultural Society, in which he held a similar position for many years. He was also interested in sports and for a time managed the Guelph Track and Field Club for boys who wished to take up running and assisted them at various meets. He was one of those men who started the Guelph Cross Country Run and Road Race Association nearly forty years ago and has been largely responsible for the outstanding success they have achieved since that time. He has served as president, general manager, and treasurer of this association on numerous occasions. Last year he was president again. He was also president of the Guelph Track Club.

He was active in the tobacco industry for more than ten years as a grower and has been secretary-treas-

urer of the Simcoe Tobacco Plantation. He was a past director of the Ontario Flue-Cured Tobacco Marketing Board.

Hydro has lost a devoted supporter. He was admired and respected by everyone in the organization who knew him. His kindly happy disposition endeared him to everyone he met and in his passing there is the feeling of the loss of a true friend.

R. N. Bassett, Whitby

On Monday, July 1st, 1940, Richard Norman Bassett, Commissioner of The Public Utility Commission of the Town of Whitby, passed away at his home. He had been in failing health for several months, but the end, nevertheless came suddenly.

Though born in Oshawa in 1880, where he received his education, he spent the greater part of his life in Whitby. In 1902 he started a jewellery business in the town. He took a very active interest in the town's growth and development, and in 1923 and 1924 was Mayor. For many years he was a member of the Public Utility Commission, holding office at the time of his death. He took a keen interest in the Ontario Ladies' College, and was a member of the Board of Directors and Treasurer of the institution for a considerable period. He also served for a time on the Court of Revision in Oshawa.

It was Mr. Bassett's ambition to modernize and improve property and his enterprise and civic pride is reflected in the business section of the town, where he was largely responsible for its modern appearance.

John Littlejohn

John Littlejohn, a retired member of the staff of The Hydro-Electric Power Commission of Ontario, died at Toronto on Saturday, July 20th, 1940, aged 80 years.

He was born at Plymouth, North Carolina, on February 22, 1860. It was not until 1911 he became identified with the electrical utility industry when he joined the Electric Power Company as Treasurer, coming from the Canadian General Electric Company, Limited. In the Electric Power Company he was in charge of all accounts. When the Company was taken over by The Hydro-Electric Power Commission of Ontario in 1916, he became auditor of the Hydro local offices in the Central Ontario system and was put in charge of insurance, taxes and rents. In 1923 he became Secretary of the Commission's Pension Board. He retired in 1934.

Wound Infections

Lieut.-Colonel W. J. Deadman, B.A., M.B., V.D.,
Pathologist, Hamilton General Hospital

THE term infection has reference to the invasion of the body through wounds or other avenues by harmful bacteria. Bacteria are among the simplest forms of life, and on account of their minute size, can be studied satisfactorily only by means of the microscope. They are considered by many authorities to be simple, one-celled members of the plant kingdom. Corresponding to them in the animal kingdom, we have the microscopic protozoa, some of which also at times invade the body and cause disease. Bacteria being living things, require much the same living conditions as do animal and man, viz. a suitable temperature, sufficient moisture, a supply of suitable food material, the right concentration of oxygen, and the proper degree of light. When these conditions of life are provided, bacteria multiply rapidly, doubling themselves approximately every half hour, if nothing interferes. It will be readily seen that one bacterium may under such conditions beget millions of his type within 24 hours.

Disease-producing bacteria may be classified in many ways, and one of the classifications is based on their taste for oxygen. The great majority, like human beings, must have a certain amount of oxygen to live, and these are called AEROBES, which is merely a Greek way of saying, living with oxygen. A smaller group appears to hate oxygen, and will not grow at all if more than the tiniest traces are present, and these latter are called ANAEROBES, which again is merely a Greek way of saying,—living without oxygen. The doctor knows that the treatment of infections must be adapted to classification, and consequently, the treatment of anaerobe infections must differ in some respects from that of aerobe.

The world teems with bacteria, but fortunately for us, less than one tenth of the known types are harmful to man. A few types are definitely useful and necessary for our existence, but the vast majority are quite harmless. With every glass of milk or water drunk, hundreds or even thousands of bacteria are taken into the body without harmful effect. The relatively few types which can produce disease in the human body are distinguished by the fact that in their growth and multiplication, they produce a substance which is poisonous to the tissues of the body, and this substance is probably simply an excretion in much the same sense as expired air is in the case of the human being. Expired air can exert a damaging effect on the human system, as the old story of the Black Hole of Calcutta indicates. This poisonous substance produced by the

Presented to the Silver Jubilee Safety Convention of the Industrial Accident Prevention Associations, Incorporated, at Toronto, April 23, 1940.

growth of bacteria is known as a toxin which is Greek for poison.

The body has normally several good lines of defense against these poisonous bacteria, otherwise few, if any of us, could survive. The first line of defense is healthy skin and healthy lining membranes. The body anatomically may be compared to a hollow tube, lined on the outside by the skin, and on the inside by the lining of the alimentary canal, beginning at the mouth. As long as these lining membranes are healthy and uninjured, the chance of infection is relatively small, and even in cases of severe exposure, some damage must occur to these linings before invasion takes place. But even slight wounds of the skin or damage to the lining of the alimentary canal enormously favors infection. This is why prompt first aid attention to even small wounds is so important. The secretions of the body normally keep down the growth of bacteria. The saliva is too alkaline, the gastric juice is too acid, and the intestinal contents, made alkaline by the bile, tend to prevent the growth of disease-producing bacteria. The perspiration has a high content of salt and other chemicals which discourages their growth. When they do finally invade, sterner measures must be taken, and then, the white blood cells come into play. The normal number of white cells per small drop of blood is about 5,000, and this number may be increased up to 50,000 in order to fight the multiplying bacteria. At the same time, we have the blood beginning to manufacture a substance which neutralizes the effect of the bacterium and of its toxin or poison, and this we call an anti-body. If and when enough anti-body is manufactured to more than neutralize the invader and his bad breath (toxin), the number and amount of these two factors steadily lessens and recovery is under way. But if, as sometimes happens, insufficient anti-body is produced, death will be the result unless this anti-body is artificially injected. That is the reason we prepare and use in the treatment of infections, such things as antitetanic serum, antidiphtheria serum and antistreptococcus serum.

Most infections get into the body with food or drink, by being breathed in, or through a break in the skin, which we call a wound. Let us consider particularly what happens when a wound gets infected. The invading bacterium, having found what is for it a snug home, furnished with all the necessities of life in the way of temperature, moisture, food, oxygen and light, begins to reproduce itself and in its reproduction and growth, produces its toxin or poison. This stimulates the tissue round the wound to react, and it becomes red, swollen and tender. The white blood cells increase in number and begin to gobble up the invaders, and a wall of new-formed tissue is thrown around the wound, which in most cases holds the infection to the local situation until it is overpowered and the wound heals. But sometimes the reaction on the part of the tissues and white cells is not sufficient or perhaps the invading bacteria are especially poisonous, and then the bacteria or their poison, or both, spread into the blood stream, causing a general blood poisoning,

which causes a more or less protracted illness, which will end in death unless the body is able to manufacture enough neutralizing substance or anti-body to down the invaders and protect the organs from damage, or the doctor injects an early and sufficient amount of ready-made anti-body in the form of the proper anti-serum for the particular bacterium involved.

Let us now briefly discuss a few of the commoner bacteria which may infect wounds. They fall into two groups, the aerobes which prefer a reasonable supply of oxygen, and the anaerobes which prefer little or no oxygen, and will not grow if more than a very small amount of it be present. Anaerobes, therefore, are more likely to grow in the depths of punctured or deep wounds should they infect them, and aerobes which are by far the more common causes of infection, are to be found in shallow or superficial wounds. Let us deal with *aerobes* first:—

(a) The staphylococcus aureus is one of the common infecting organisms, and is nearly always the cause of boils. When it infects a wound, there is usually a great deal of pus formed, and only rarely does it get away from the abscess and get into the blood stream. When this happens, however, the results are nearly always fatal, for it sets up one of the most dangerous types of blood poisoning.

(b) The streptococcus is a common infecting agent of wounds, and is considered to be the cause of such diseases as erysipelas and scarlet fever. When it infects a wound, there may not be a great deal of pus formed, and it does not appear to be so easily confined to the wound and consequently the danger of blood poisoning is always present.

(c) The bacillus coli lives normally in the intestine and renders very valuable aid in digestion. When, however, it gets into wounds or other parts of the body, it sets up inflammation and causes the formation of pus, thereby preventing the wound from healing. It is perhaps the least dangerous of the three organisms.

(d) The bacillus of anthrax is now a very rare cause of infection of wounds, and as it is the organism causing a disease of cattle, is to be considered in connection with hides or bristles. It causes a skin pustule which has been called "malignant pustule", and when it invades the blood stream, causing blood poisoning, the result is nearly always death.

There are two principal *anaerobes* to be considered:—

(a) The bacillus tetani (bacillus of lockjaw) is a very dangerous invader of wounds, especially as before stated, of deep or punctured wounds. It is found mostly in the soil and therefore wounds which may be soil contaminated are most likely to suffer infection by this organism. In its resting period, it goes into a shell or spore, hibernating somewhat as the groundhog does, until it again finds itself in surroundings suitable for growth. In its growth in the wound, it produces a very powerful poison or toxin which damages nerve tissue, and this is why intense muscular spasm is such a characteristic feature of the disease. It does not wander from the wound, but sends out into the blood stream its toxin.

(b) The bacillus aerogenes (gas bacillus) is also found in soil and like the bacillus tetanus, it can hibernate in a shell or spore stage, and unlike it it is not inclined to stay in the wound. It also produces a strong poison which destroys the tissues, and in destroying them, produces a gas. It spreads with great rapidity when it starts, and its progress through the tissues may be followed by a crackling sensation to the examining fingers. Blood poisoning is set up when it spreads, and it is a very dangerous source of infection.

In conclusion, it may be repeated that a whole skin is the first line of defense of the body against the invasion of disease-producing bacteria through the outer surface of the body. Wounds, therefore, however slight, deserve prompt attention, and this is the field of the first aid man. The prompt application of iodine, or of other suitable antiseptics kills the few bacteria which may be originally present, and prevents their growth, multiplication and toxic production. This enables the tissues to heal in the natural way. Wounds of any severity need the doctor's attention, and all deep or punctured wounds, or wounds which may have suffered soil contamination, directly or indirectly, should have his immediate attention.

Accident Investigation and Regular Plant Surveys

By D. W. Smith, B.Sc., Engineering Department, Ford Motor Company of Canada Limited, Windsor

I AM going to try to give you some idea of the methods we use in our Ford Plant at Windsor, and to give you some idea of our problems.

Some people will tell you that the problems in a large plant are different from those in a small plant. We have a large plant. There are some reasons why accident prevention is easier in a large plant, but on the other hand there are some difficulties which you would not encounter in a smaller one.

At the present time we have more than 7,000 employees in the Windsor plant alone. Since The Workmen's Compensation Act was passed in 1915, our surplus of assessment over medical aid and compensation has been 30 per cent. Last year our surplus was over 45 per cent, in spite of the fact that our assessment rate was lowered by 25 per cent of the average rate for these years. Actually in our particular group the rate has been around 55 cents, and last

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An address to the Silver Jubilee Safety Convention of the Industrial Accident Prevention Associations, Incorporated, at Toronto, April 23, 1940.

year the rate was 40 cents. These are round figures. Last year we had a fair surplus and I think the figures show that we are at least working along the right lines.

We do not take the time to investigate in all detail the general run of small accidents and minor injuries. However, we do investigate all accidents which result in lost time, all accidents reported to The Workmen's Compensation Board, and such other accidents as seem to warrant special investigation, even though these may not have caused an injury. Notice that I don't refer to an accident as something that has caused an injury. If there is a change in the weather, windows are opened and we may get an epidemic of dust in the eyes. This does not warrant a special investigation.

On the other hand, there are some accidents which we do investigate fully.

The main reason for making a thorough investigation is to find the fundamental cause of the accident. This is done so that we can take steps to prevent similar accidents. The condition which has caused an accident in one department may prevail in several departments and we can correct it in all. For example, one of our electricians wanted to blow the dust out of a d.c. motor, so he took a hose and attached it to one of the natural gas lines. For some reason or other he did not notice the strong smell of the gas. Fortunately there was no explosion. After that we put signs on all the gas outlets.

Now, another reason for a thorough investigation is to obtain and make a record of all the facts in connection with the accident, so that details will be available later if required by the Workmen's Compensation Board.

The investigation should be made just as soon as possible after the accident. First, in order that conditions will be unchanged; second, in order that equipment, including machines, will not have been moved or put back into production; and third, in order that any witnesses will be available. For example, they may go home with a change of shift. You want to get the facts before the witnesses or others concerned have time to think up a good story. That is very important sometimes. We have a standing order with our Watch Department that in case of a serious accident some member of our Safety Division must be notified at once, regardless of the hour.

If an accident is serious, we make measurements of equipment which is likely to be moved, and of anything not of a permanent nature. Some time ago one of our employees was knocked down by an automobile in front of the plant gate. We took measurements to locate a little spot of blood on the road. The Board turned the case down as not coming under the Workmen's Compensation Act because our measurements showed that the accident had occurred outside the plant and the man was not yet at work.

Any eye-witnesses should be questioned fully. In the case of a serious accident you may not be able to get much information from the injured

man for some time as he will be suffering from shock and should not be questioned. That is important.

Avoid putting words in a man's mouth. That may sound strange but it is a common occurrence. If the injured man is of foreign extraction, he may not speak very good English. Moreover, he is not concerned about the cause of the accident, so it is difficult to avoid helping him to answer the questions. Unless care and patience are exercised by the man who is making out the report, the true story will not be obtained.

We also like to find out how long a man was doing this certain job before he was hurt, and what instructions he got from his foreman. We often find that the man was doing the operation the unsafe way for a long time and the foreman should have corrected him. Sometimes a man is hit by a train the first time he neglects to look for it, but I think that in the majority of cases the man who is hit on the railway track is the man who never looks to see if a train is coming, and eventually the train will get him.

We have the example of a case that happened some time ago. A man cut his finger brushing away chips from a drill press. Naturally, a man shouldn't use his fingers to brush chips from a machine. He cut his finger slightly, had a little bandage put on in the First Aid room and went back to work. He profited so much by his first injury that, that afternoon, working on the drill press, he brushed away some more chips, caught the bandage in the machine, and got a very severely torn finger. There is no doubt about it, had the foreman been on the alert, he would have seen the man brushing the chips off with his fingers, and I think could have prevented such an accident.

If you make a full investigation, you should be able to arrive at the cause of an accident. Often we are surprised by what we find.

Some time ago we had a carpenter who lost the tip of his finger. On investigation we found that this man had been working with wood working machinery about forty years. Now, it is obvious that the man wasn't a careless worker, because if he had been working around wood working machinery for forty years and had been careless, certainly he would have lost a finger long before that time. We couldn't explain the accident. We eventually found that this man's son had got into trouble at home and it was perfectly obvious that the man's mind was not on his work at all. Things of that type are pretty hard to prevent.

I am going to give an example of poor judgment. We have a drawbridge across a railway track. The angle iron guard rail of the bridge was removed for repairs. The millwright who went to make the repairs took the iron guard rail off and put up a two by four post at each end, with a rope between the posts. It looked like a perfectly good guard. There was a truck standing on this bridge and one of the stockmen went to check the contents. He wasn't very observant, so he leaned against what he thought was the iron guard rail. Instead of that, the rope gave and he fell off the drawbridge and

hit his head on the railway track below. It might have been a very serious accident. In this case, he didn't have concussion and it wasn't a very serious thing. The chief of our Millwright Department explained to the man who did the job the fact that he showed very poor judgment. I don't think a thing like that will occur again.

Now, I want to give an example of laziness. We have a piece of apparatus that we call a Jim-Jam. I don't think the name is very scientific, and I don't even know that it is common. The Jim-Jam consists of four posts with castors at the bottom, and the tops bolted to a square framework. The bottoms of the posts are fastened together with four removable steel tie rods. The whole strength of the apparatus depends, of course, on these tie rods. The top framework supports a long wooden beam to which is fastened a chain-fall. The Jim-Jam is used to remove motors from certain machines where it is not easy to fasten a chain-fall overhead. The department that owned the Jim-Jam was a Tool Repair Department. It had been moved, and for some reason the tie rods had been left at the old location. One of the men tried to use the Jim-Jam without the steel tie rods. He started to lift a motor up, and two of the cross bars that supported the heavy beam broke and the thing came down and hit the man on the head. It is not in every case that a man who does a silly thing like that gets his just reward so quickly. It didn't do a great amount of damage but it didn't improve him at all. When I spoke to him about it I said, "You know you should have had the tie-rods on, don't you?" He said, "Yes, as a matter of fact I was too lazy to go back and get them".

An other example is of a man working on a steel scrap baler. He had his wrist pierced by a piece of sharp steel. The man on the scrap baler is supposed to wear a leather glove or gauntlet. One of the Inspectors brought back the report and I said, "Let me see the glove". I am inclined to be from Missouri. In Windsor we are south of the border, so that may account for it. On further investigation the Inspector found that the man had been wearing a glove, but it was not the kind he was supposed to have. It was a short glove instead of the gauntlet type.

As you can imagine, in a modern plant, we don't find that many accidents are due to faulty equipment. We consider the idea of the "accident-prone" employee as more or less bunk. I think you have to go into the matter a little more fully than that.

We find that some accidents are due to the fact that the man is not suited to the job. He may be too slow in his reactions. For example, on a small light punch press you shouldn't put a big, heavy man, with fairly slow reactions. We have some men who do nothing but move heavy machines. They are pretty husky fellows whom you would hardly consider putting on a small light punch press. That is just using common sense.

Again, a man may be too old for a certain job, or he may be sick. For instance, we have some millwrights

who have got on in years. We don't let those men climb around high spots. We keep them on the ground.

In other cases we find that the accident occurred because a man wasn't given proper instructions or training. These are conditions which we try to correct.

Now, so much for that phase of the subject. We will now go on to regular plant surveys.

Some time ago our Chief Engineer gave me a clipping—"Not because we think the plant unsafe, but to make sure the plant is safe." He had put the word "plant" in place of "ship" on the original clipping. That sums up in a few words why regular plant surveys are necessary.

I shall confine my remarks to general plant surveys which we consider as more or less part of maintenance. In this connection you will be interested in hearing that the floor areas of our buildings total about 47 acres. We believe that cleanliness is of primary importance and every year we use over eight tons of soap and cleaning compound to keep the plant clean.

I have heard some of the speakers mention that safety has to start higher up. We are fortunate in that respect. Our President, Mr. Campbell, certainly takes a keen interest in the work. Not very long ago, as I was going into the foundry, I met Mr. Campbell coming out. He said, "You are just the man I am looking for". He took me in and showed me a pile of hubs, which he had noticed were not piled in a safe manner. At that time Mr. Campbell had heavy responsibilities outside of our plant, yet he found time to check unsafe conditions.

We have medical inspection of all new employees, and in certain cases we have periodic inspections. For instance, we take blood tests of our men in our body building department. We are using less and less lead, so of course we are getting away from some of the troubles resulting from its use.

We test the eyes of our truck drivers—that is a periodic job—and we take X-rays of the men working in the foundry. Within a month or two of a man's being employed in the foundry a chest X-ray is made and followed up by periodic X-rays.

Then, of course, we have our Safety Inspectors, making daily checks around the plant to see that our safety rules are being enforced. They see that the men are wearing goggles, leather wrist protectors, hand pads, steel studded gloves for the men handling sharp sheet metal, and so on. They see that only qualified men are using welding equipment, and that safety cans are in their proper places. A word in connection with the colour of safety cans. It seems strange that when we buy a safety can it is painted red. So is all fire-fighting equipment. I don't know whether fire pails of sand and water are common now, but they always used to be painted red. In Detroit, some time ago there was quite a disastrous fire. A man picked up a red can containing gasoline and threw it on the fire. It didn't help very much. We believe that yellow is the right colour for our safety cans, so we have painted them yellow and have la-

belled them. We use red only for our fire-fighting equipment.

We have our watchmen making their rounds twenty-four hours in the day. In the old days watchmen often got their jobs because they were too old to do anything else. Now we choose them very carefully. This is particularly important, I think, at the present time. They must be active and observant. As you know, much of the patrol work is done at night when it is more difficult to see than in the daytime.

I want to make this point clear. We don't pick only young men in our Watch Department or anything like that. But we don't take all the older men from all over the plant and put them in our Watch Department. We have older men in the Watch Department, as in other places, but we don't use the department as just a place to put them when we don't know what else to do with them. We make each department absorb and carry its own older men.

Our watchmen are taught to be on the lookout for all unsafe conditions. Naturally they are on patrol all the time and we expect them, if they see a man not wearing goggles to let us know about it, or to speak to the man directly.

As a matter of fact, the Safety Inspector also makes a point, not only of speaking to the man, but also to his foreman. Incidentally, we keep track of these warnings in a book, so that at any time we can turn it up and find how many times the man had been warned.

Our watchmen are always called when any cutting or welding jobs are being done around the plant, unless it is being done in a special construction department. One of them stands by with a fire extinguisher, and he remains on duty while this work is being done. We believe this procedure has prevented many costly fires.

Then we have electricians making regular inspections of all electric motors and equipment. We have something like 5,600 individual electric motors.

Our Sheetmetal Department inspects guards, duct work and outside stacks.

The Millwright Department inspects conveyors, of which we have over ten miles. They also inspect ovens, machines, cranes and so on.

The Chief of our Millwright Department has a good idea that I might pass on to you. He has a man going around at night checking certain conditions and this man isn't responsible to any of his foremen, or anyone like that. He makes his report direct to the Chief Millwright. If he finds anything neglected he reports directly to the Chief Millwright and it is taken care of.

The oilers come under the Millwright Department. In that connection I might say that the Chief of the Millwright Department usually insists on the men going up on a ladder to do their work. He doesn't like to have them use a long pipe to put in the grease from the ground. Frequently when they climb up they find a condition which needs to be remedied and that might not be noticed from the ground.

These oilers are being picked very carefully for the job and it is considered a very good job.

Then the Millwrights, as a whole, are taught to be on the lookout for any unsafe equipment, planks left overhead, and that sort of thing. All of our hook-up men are in the Millwright Department, so they come under one head. That has worked out very well.

Whenever a crane is used a hook-up man and a crane operator must be called, even if it is to make only one lift for a few men working overtime. We find that it pays to go to this trouble. The men think that they could move the crane themselves, but it is not much of a thing to take a joyride in.

The men of the Steam Department inspect valves, piping, gauges, etc., on gas, air and steam equipment.

All chains used on our cranes are numbered with brass tags and are given a monthly inspection, with a full record kept in a book. All the chains are annealed once a year. For lift chains we use only dredge quality wrought iron chains. We cannot use that for chain-falls because the links aren't true enough. Our chain-falls used on the hot lines in the foundry are inspected every day. We lift a test weight and then check the chain carefully. The test weight is kept in a covered pit in the floor. In making a test we merely lift the weight an inch or two off the floor of the pit. We make a visual inspection all over and it is surprising what this shows up. Then, about every three months or so, the chain-falls are taken apart and inspected for internal wear.

Our elevators are inspected every six months and this is in addition to any inspection we may get from outside insurance company inspectors.

The general maintenance of roofs, roadways, signs, etc., is taken care of by our Labour Department. In connection with signs, we don't like to have many up, but those we do put up have to be kept in good shape. Our standard signs are yellow letters on a black background. Of course the reason for using a black background is that it is very easy to get a good solid black paint, and from time to time, when necessary, it is easy enough to touch up the letters. We use a varnish to protect the surface.

Pressure vessels are all marked with a special brass tag, and listed. In addition to our own inspection, we have an insurance company inspect them once a year. We try to use every possible outside inspection service, for we think the more often we check things the better, and an inspector in our own plant may pass something which an outsider might spot at once.

We work very closely with the resident representative of the industrial Accident Prevention Associations and we do not hesitate to call on the Associations for help whenever we need it. We use any service of that nature that we possibly can.

Safety, like maintenance, is a never-ending job.

C.E.S.A. Approvals Manual, 1940

BEGINNING on May 1st, 1940, the Canadian Engineering Standards Association inaugurated its Approval Service, when all such work in Canada came under its supervision. In conjunction with this inauguration the C.E.S.A. Approvals Division has prepared an Approvals Manual respecting inspection, test and approval of electrical equipment. The manual contains general information as to Approvals and also the procedure necessary to obtain approval of any electrical equipment coming under the scope of C.E.S.A. Approvals, together with Schedules of Approvals Fees.

The first section of the Manual gives general information respecting C.E.S.A. Approvals. It outlines the classes of equipment to which the Approvals Service is applicable, the basis of Approvals work and the requirements for Approval. This section also refers to special equipment, labels, follow-up inspection service and the application of the Approvals Service and special inspections.

The section on Procedure Respecting C.E.S.A. Approvals defines the methods to be followed to obtain Approvals. This covers applications, submission of samples, Approvals reports and issuing of Approvals both for first inspection and also follow-up inspection and re-examination service.

The Schedules of Approval Fees are classified under label service, prices of labels, limited label service, re-examination service and listing. The Manual closes with the names of those who act in an advisory capacity in the operation of the Approvals Division forming the Approvals Administrative Board and the Approvals Council.

Manufacturers desiring to obtain the approval of the C.E.S.A. in respect of electrical equipment, or others interested, may obtain copies of the Approvals Manual from W. R. McCaffrey, Secretary, Canadian Engineering Standards Association, National Research Building, Ottawa, Ont.

O.M.E.A. Acting Secretary

After the death of T. J. Hannigan, his secretary, Miss K. Ciceri, was appointed Acting Secretary of the Ontario Municipal Electric Association. She was also appointed Acting Secretary of the Municipal Hydro Electric Pension and Insurance Committee. All correspondence pertaining to these two organizations should therefore be addressed to

Miss K. Ciceri
Acting Secretary
Ontario Municipal Electric Association
Guelph
Ontario.

Distribution Is Meeting Its Responsibilities

By H. P. Seelye, Detroit Edison Company

WHETHER the product is automobiles, breakfast cereals or kilowatt-hours, a large part of the responsibility for the quality of the service given to customers and the cost of rendering that service lies in the distribution facilities. For every dollar a power company invests in its electrical property about 33 cents is spent at the discretion of those responsible for distribution. The importance to the company and its customers of the proper and careful use of that money is obvious.

A distribution system, like that of the Detroit Edison Company, for example, contains more than one-half million poles, 75,000 individual distribution transformers and more than one-half million separate services, spread over 7,500 square miles of territory.

Necessarily Rugged

It is important that simplicity and ruggedness in this equipment be emphasized. The lines are on their own. They are battered by wind, snow, rain and sleet. They are loaded with ice accumulation one month and scorched by the summer sun another. They are attacked by rust, decay, insects, birds, boys and vehicles. They are shaken, vibrated, whipped and generally mistreated. Only occasionally does someone come around to see if they are getting along all right unless a failure occurs. For such service the devices used must be good and they should be as simple as possible. Complicated gadgets must be avoided—and an innumerable lot of these are offered to solve all our problems. Otherwise, service quality will go down and maintenance costs up.

On distribution, the practice of ten-cent-store economy is particularly profitable. A few cents saved on a particular item may look small, but the engineer must remember his multiplication table. The quantities of small items, bolts, insulators, pins, braces, etc., used each year are enormous, and a little saving in each should not be ignored. To give a small but typical example, we formerly cut the tops of our poles to a peaked roof, but this was found to be unnecessary. It cost something like 15 cents, and what is that on a three-hundred-million-dollar system? For 30,000 poles a year, however, it amounts to $4,500 each year, which is equal to the fixed charges on an investment of about $30,000.

The a.c. low-voltage network scheme of distribution has been developed and perfected until today it is accepted as an adequate means of serving densely loaded areas where high reliability is essential

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Abstract of paper to Edison Electric Institute Convention, 1940.

and lines must be underground. One hundred and twenty cities have such networks in operation.

Protection Afforded

Today we have reached a point where very effective protection against lightning damage is possible. The degree of protection afforded by a given design can be predicted quite closely. That degree can be increased, by increased expenditures, to a level at which only rare cases of damage are to be expected. The economical level depends, of course, on the relative importance of the service.

The impulse strength of insulators has been studied and the high impulse strength of wood in poles, crossarms and braces has also been recognized. Wood arms are sometimes used on steel towers for added insulation against lightning. Wood crossarm braces are now commonly employed on wood-pole construction for the same purpose, where formerly steel braces were customary. Guys are frequently insulated with wood guy insulators.

The practice of protecting each transformer by lightning arresters, interconnection of the arrester ground connection with the grounded secondary neutral, low ground resistance for the arrester ground—these measures have been quite generally reported to have effected a reduction of some 40 per cent in transformer burnouts due to lightning. It also reduced the blowing of primary fuses, the reduction being as much as 75 per cent on one system. Modern lightning protection has reduced transformer damage to relatively insignificant amounts. The percentage is of the order of one-half of 1 per cent per year, varying, of course, considerably between different localities.

Economical Loading

The possible economy of utilizing distribution transformer capacity as fully as practicable, without going to a point where service is endangered, is considerable. An average loading of 50 per cent for a system is not uncommon. It is hard to raise this a great deal for scattered suburban and rural load, but urban loading can average well above 75 per cent, and 100 per cent or over is possible under favourable conditions. Distribution transformers constitute something like 3 per cent of the total plant investment. An increase of 1 per cent in the average loading from an average of 75 per cent is equivalent to a saving of 0.045 per cent of the total investment. For a 100-million-dollar plant this would amount to a saving of $45,000 for each 1 per cent that the average loading could be increased, or $450,000 if a 10 per cent increase were possible.

Transformer spacings of the order of 700 to 800 ft. are suitable. The difference in cost over a reasonable range of values, such as from No. 4 to No. 1 wire, is not great. When contrasted to a design using a considerably larger wire size, however, the difference may be of the order of $100 per 1,000 ft. of line, or about $6,000 per square mile of territory. This can amount to a considerable sum if the area served has many square miles.

Increasing use of secondary banks is one means whereby careful engineering has produced improvement in quality at little or no increase in cost.

A line of step-type regulators and automatic boosters has been recently brought out at appreciably lower cost. These are applicable on the lighter circuits and also at intermediate points along the line on long circuits. They make it feasible to hold service voltage within closer limits on scattered suburban and rural lines.

The sectionalizing of long or branching circuits in order that a fault on one section may be automatically cleared without interrupting service on the whole circuit has become prevalent. This practice has been promoted by the improvement in quality of fuses, making them more reliable and more easily coordinated from section to section. The introduction of reclosing fuses which automatically insert a new fuse after the first one has blown and of the small reclosing circuit breaker for pole mounting has contributed to the reduction of long outages. These act to restore service after it has been interrupted by a temporary fault.

Line splices and tap connectors for making wire joints without solder and without special tools have come into common use. It has been possible to eliminate soldering equipment from the construction wagons and work has been facilitated, particularly that of repairs and changes.

It seems reasonable to expect increased density of loading and, along with it, an increasing demand for greater perfection of service quality.

A Look at the Future

It is probable that the use of underground facilities will increase. This will be caused not only by the desire for improving the appearance of streets and other property, which is likely to be a factor, but also due to the increasing congestion of lines which accompanies larger loading. It is improbable, however, that the cost of underground distribution will ever approach very close to the low cost of overhead distribution, which has been a major element in the rapid expansion of the use of electric power in the past.

No radical changes in materials or methods can be foreseen, however, which will lead to major reductions in the cost of distribution.

There is the probable tendency toward higher priced construction, such as a greater use of underground lines. The outlook is toward increased costs for distribution instead of reduced costs, except for one factor. Quite a large part of the investment in distribution is in such things as poles and wires which can carry considerably more load without proportional increase in cost. In addition to this, most of the cost of distribution lies in the "ready-to-serve" investment, or the charges on the investment necessary to meet the peak demand in kw., rather than the consumption in kw-hrs. A considerable increase in kilowatt-hours is possible by enlarged use of energy by the customer, without increasing the demand appreci-

ably and hence without increasing the investment in distribution. The solution for reducing distribution cost, therefore, lies very largely in the commercial departments—in the increase in load per customer, and particularly the increase in energy use.—*Electrical World.*

Growth of Revenue and Consumption

Hydro Domestic and Commercial Lighting Consumption and Revenue Compared by Years

THE following tables show the growth in consumption and revenue from year to year since 1913, for domestic and commercial consumers. Each class is divided into tables showing totals for cities with a population of 10,000 or more, towns with a population of over 2,000 and villages with a population under 2,000. The tables include all the municipalities as shown in statement "D" of the Annual Report, as well as those municipalities owned and operated by the H.E.P.C.

The increase of 1939 over 1938, in both consumption and revenue, indicates that the growth of the use of electricity is being well maintained and that the Commission's promotional activities are showing results.

DOMESTIC SERVICE

Table No. I shows that the domestic consumers in cities are continuing to make more use of electrical appliances. The average monthly consumption rose from 182.6 kw-hr. in 1938 to 188.3 kw-hr. in 1939. The average cost per killowatt-hour is now down to 1.17 cents.

Table No. II shows that domestic consumers in towns have increased their average consumption from 137.5 kw-hr. in 1938 to 143.1 kw-hr. in 1939 with an average cost of 1.44 cents.

Table No. III shows that domestic consumers in villages have an average consumption of only 109.5 kw-hr. with an average cost of 1.76 cents.

Table No. IV gives a summary of all domestic consumers in all municipalities and may be compared with its component parts for the year 1939 as follows:

	Average Cost per kw-hr.	Average Monthly Bill	Average Monthly Consumption kw-hr.
All Domestic Consumers	1.26c.	$2.14	169.9
Cities	1.17	2.20	188.3
Towns	1.44	2.05	143.1
Villages	1.76	1.93	109.5

The growth in the use of electricity by domestic consumers is also illustrated by graphs.

Graph No. 1 shows the average cost per killowatt-hour as given in Tables Nos. I, II, III and IV.

Graph No. 2 gives the variations in the average monthly bills from the same tables.

Graph No. 3 shows the growth in the average monthly consumption.

Commercial Service

The tables and graphs on the revenue and consumption of commercial consumers shows the effect of improved store lighting and industrial conditions.

Table No. V shows a twenty-five million increase in kilowatt-hours used by commercial consumers in cities with an average monthly consumption of 591.2 kw-hr. and an average cost per kw-hr. of 1.5 cents.

Table No. VI gives similar data for towns.

Table No. VII gives similar data for villages.

Table No. VIII is a summary of all commercial consumers and may be compared with its component parts as follows:

	Average Cost per kw-hr.	Average Monthly Bill	Average Monthly Consumption kw-hr.
All Commercial Consumers	1.58c.	$7.66	485.2
Cities	1.50	8.87	591.2
Towns	1.70	5.85	344.5
Villages	2.31	4.50	194.5

The results shown in Tables Nos. V, VI, VII and VIII are graphically illustrated in Graphs Nos. 5, 6 and 7.

TABLE NO. I

Data for Cities over 10,000 Population

DOMESTIC SERVICE

Year	No. of Municipalities	Annual Revenue	Kilowatt-hours Consumed	Number of Consumers	Average Cost Per kw-hr.	Average Monthly Bill	Average Monthly Consumption kw-hr.
1914	12	$ 614,925.00	12,646,400	55,597	4.86¢	$1.06	21.8
1917	19	1,063,264.00	36,693,100	107,248	2.89	.88	30.5
1920	21	1,926,924.00	84,328,000	154,186	2.29	1.11	48.4
1923	21	3,772,416.00	206,266,200	223,028	1.83	1.53	83.5
1926	21	5,374,069.00	324,290,285	255,109	1.66	1.80	108.0
1929	26	7,530,748.75	497,102,897	309,645	1.51	2.08	137.2
1932	26	8,491,082.70	593,618,860	323,844	1.43	2.18	152.8
1935	26	9,096,420.26	664,178,767	335,467	1.37	2.26	165.0
1938	26	9,426,825.47	792,450,767	361,669	1.19	2.17	182.6
1939	26	9,672,757.10	827,446,879	366,179	1.17	2.20	188.3

TABLE NO. II

Data for Towns over 2,000 Population

DOMESTIC SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Consumers	Average Cost Per kw-hr.	Average Monthly Bill	Average Monthly Consumption kw-hr.
1914	19	$ 90,330.00	1,414,500	7,410	6.38¢	$1.11	17.4
1917	27	180,075.00	3,824,600	15,731	4.71	1.01	21.4
1920	36	353,915.00	10,053,100	24,041	3.50	1.26	36.0
1923	43	651,499.00	25,411,300	34,135	2.56	1.57	60.1
1926	48	1,037,016.00	50,487,035	47,873	2.05	1.84	89.6
1929	54	1,474,547.24	68,283,456	57,699	2.16	2.11	97.8
1932	59	1,595,906.55	81,054,613	62,843	1.97	2.11	107.5
1935	61	1,653,183.06	88,554,262	66,495	1.87	2.07	111.0
1938	60	1,689,908.10	113,673,154	68,894	1.49	2.04	137.5
1939	63	1,785,220.67	124,373,708	72,441	1.44	2.05	143.1

TABLE NO. III

Data for Villages under 2,000 Population

DOMESTIC SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Consumers	Average Cost Per kw-hr.	Average Monthly Bill	Average Monthly Consumption kw-hr.
1914	18	$ 24,913.00	291,000	1,859	8.55¢	$1.10	13.1
1917	77	97,516.00	1,412,500	8,334	6.90	.96	14.0
1920	109	233,819.00	3,829,900	15,665	6.00	1.29	21.2
1923	142	531,505.00	11,249,100	29,689	4.72	1.59	33.7
1926	174	942,309.00	29,945,632	46,900	3.15	1.71	54.4
1929	193	1,251,564.03	45,755,369	57,075	2.68	1.80	67.2
1932	213	1,589,233.10	66,226,945	65,928	2.40	2.01	83.7
1935	215	1,643,932.71	74,239,844	69,303	2.21	1.98	89.3
1938	226	1,763,446.86	97,365,532	76,569	1.81	1.92	106.0
1939	228	1,842,920.38	104,489,522	79,503	1.76	1.93	109.5

TABLE NO. IV

All Municipalities Totalled

DOMESTIC SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Consumers	Average Cost Per kw-hr.	Average Monthly Bill	Average Monthly Consumption kw-hr.
1914	49	$ 730,168.00	14,359,100	64,866	5.08¢	$1.05	21.0
1917	123	1,340,855.00	41,930,200	131,313	3.20	.91	28.6
1920	166	2,514,658.00	98,211,000	193,892	2.56	1.15	44.6
1923	206	4,955,420.00	242,926,600	286,852	2.04	1.54	75.7
1926	243	7,353,394.00	404,722,959	349,882	1.81	1.79	98.4
1929	273	10,256,860.02	612,141,722	424,419	1.67	2.05	122.5
1932	298	11,676,222.35	740,900,418	452,615	1.57	2.15	136.4
1935	302	12,393,536.03	826,972,873	471,265	1.50	2.19	146.2
1938	312	12,880,180.43	1,003,489,453	507,132	1.28	2.12	164.9
1939	317	13,300,898.15	1,056,310,109	518,123	1.26	2.14	169.9

TABLE NO. V

Data for Cities over 10,000 Population

COMMERCIAL LIGHTING SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Consumers	Average Cost Per kw-hr.	Average Monthly Bill	Average Monthly Consumption kw-hr.
1914	12	$ 536,350.00	14,048,500	12,439	3.80¢	$3.94	103.7
1917	19	642,989.00	27,479,800	19,573	2.34	2.96	126.6
1920	21	1,103,599.00	50,358,000	25,505	2.19	3.77	172.0
1923	21	2,043,197.00	91,146,500	32,016	2.25	5.56	246.9
1926	21	3,393,186.00	147,581,714	40,675	2.30	7.08	308.0
1929	26	4,772,209.30	230,263,364	48,713	2.07	8.49	401.5
1932	26	5,088,113.49	254,512,316	51,753	2.00	8.19	409.8
1935	26	5,286,039.72	273,302,264	50,835	1.93	8.66	448.0
1938	26	5,439,553.40	353,678,032	52,986	1.54	8.55	556.2
1939	26	5,681,059.37	378,726,206	53,383	1.50	8.87	591.2

TABLE NO. VI

Data for Towns over 2,000 Population

COMMERCIAL LIGHTING SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Consumers	Average Cost Per kw-hr.	Average Monthly Bill	Average Monthly Consumption kw-hr.
1914	17	$ 71,457.00	1,362,000	2,393	5.25¢	$2.61	49.8
1917	27	134,730.00	3,100,600	4,107	4.35	2.76	63.5
1920	36	221,867.00	6,179,400	5,736	3.59	3.30	91.8
1923	43	315,530.00	9,598,000	7,086	3.29	3.76	114.3
1926	48	430,467.00	15,709,616	8,310	2.74	4.31	160.0
1929	54	632,010.30	26,240,436	10,214	2.41	5.13	213.1
1932	59	723,774.94	31,786,728	11,359	2.28	5.31	233.2
1935	61	717,248.27	32,555,348	11,310	2.20	5.28	239.9
1938	60	750,601.74	42,243,795	11,159	1.78	5.60	315.4
1939	63	820,003.15	48,244,514	11,669	1.70	5.85	344.5

TABLE NO. VII

Data for Villages under 2,000 Population

COMMERCIAL LIGHTING SERVICE

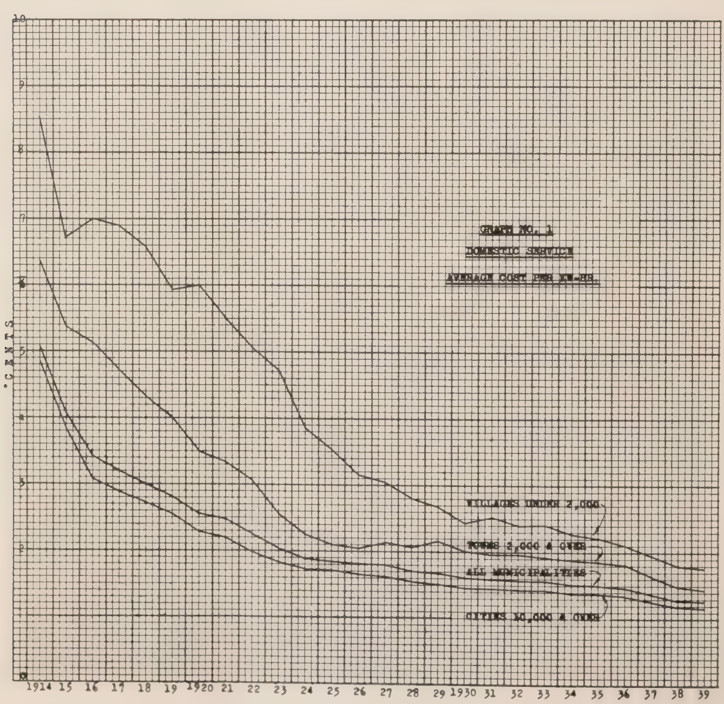
Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Consumers	Average Cost Per kw-hr.	Average Monthly Bill	Average Monthly Consumption kw-hr.
1914	14	$ 16,974.00	259,200	825	6.55¢	$1.74	26.6
1917	77	82,756.00	1,403,100	3,773	5.86	1.87	31.7
1920	109	152,497.00	2,799,500	5,255	5.89	2.45	45.0
1923	142	254,530.00	4,738,100	7,281	4.80	2.96	55.1
1926	173	352,942.00	8,505,684	9,459	4.15	3.22	77.7
1929	193	488,997.65	15,839,530	11,179	3.08	3.70	119.9
1932	213	590,994.43	20,297,499	12,593	2.91	3.91	134.3
1935	215	598,173.03	21,555,809	12,739	2.77	3.91	141.0
1938	226	719,298.87	31,099,014	13,876	2.31	4.32	186.8
1939	228	755,199,53	32,664,380	13,997	2.31	4.50	194.5

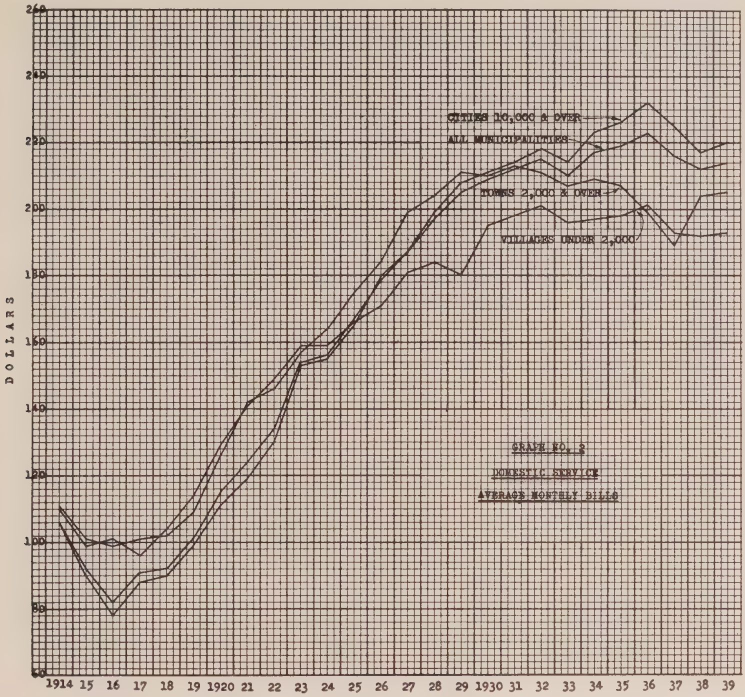
TABLE NO. VIII

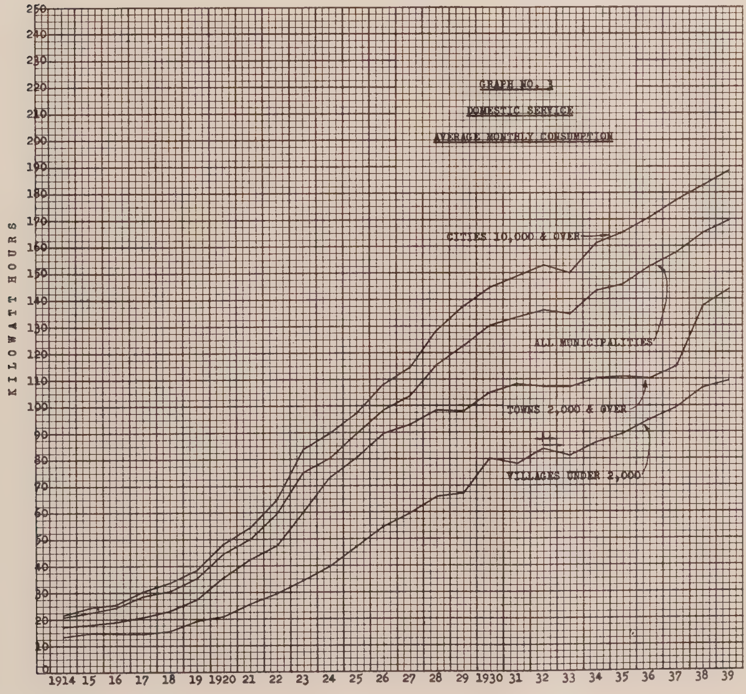
ALL MUNICIPALITIES TOTALLED

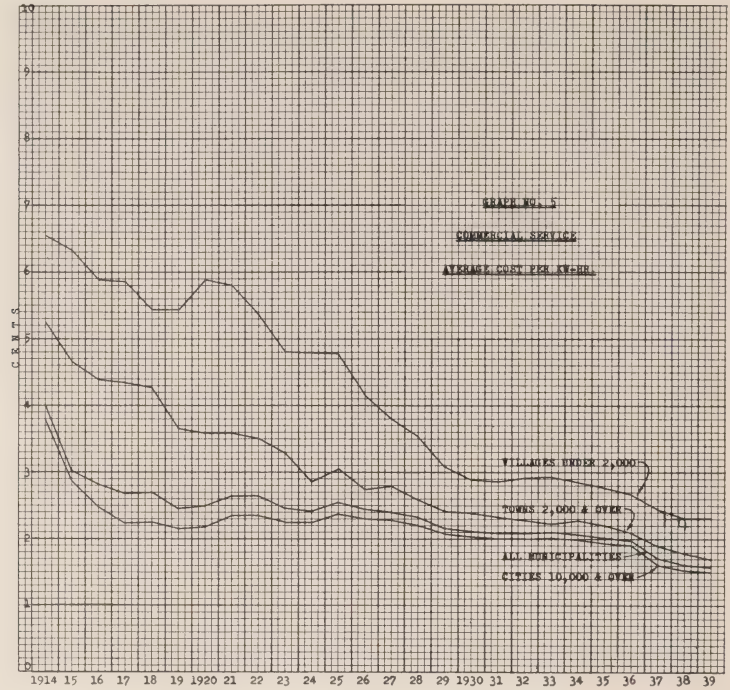
COMMERCIAL LIGHTING SERVICE

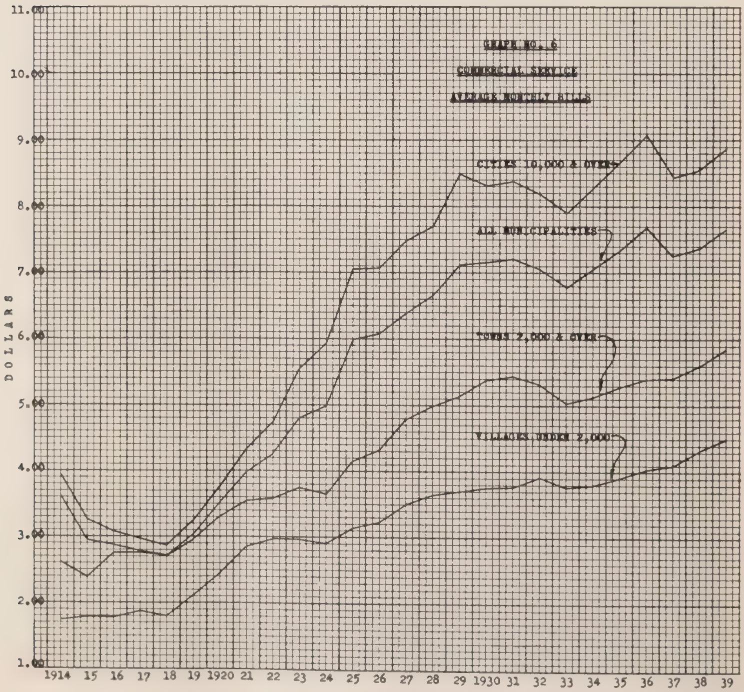
Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Consumers	Average Cost Per kw-hr.	Average Monthly Bill	Average Monthly Consumption kw-hr.
1914	43	$ 624,781.00	15,669,700	15,657	4.00¢	$3.63	90.8
1917	123	860,475.00	31,983,500	27,453	2.69	2.77	103.1
1920	166	1,477,963.00	59,336,900	36,496	2.50	3.51	140.0
1923	206	2,613,257.00	105,482,600	46,383	2.46	4.80	195.6
1926	242	4,176,505.00	171,797,014	58,444	2.43	6.08	250.0
1929	273	5,893,217.25	272,343,330	70,106	2.16	7.11	328.6
1932	298	6,402,882.86	306,596,543	75,705	2.09	7.05	337.5
1935	302	6,601,461.02	327,413,421	74,884	2.02	7.35	364.3
1938	312	6,909,454.01	427,020,841	78,021	1.62	7.38	456.1
1939	317	7,256,262.05	459,635,100	78,949	1.58	7.66	485.2

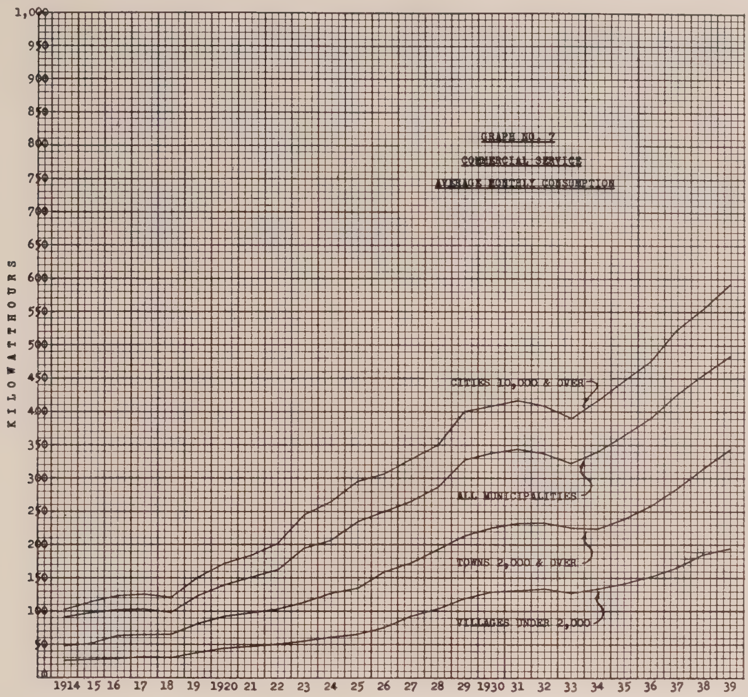



CITIES 10,000 & OVER
ALL MUNICIPALITIES
TOWNS 2,000 & OVER
VILLAGES UNDER 2,000
GRAPH NO. 2
DOMESTIC SERVICE
AVERAGE MONTHLY BILLS
DOLLARS
260
240
220
200
180
160
140
120
100
80
60
1914 15 16 17 18 19 1920 21 22 23 24 25 26 27 28 29 1930 31 32 33 34 35 36 37 38 39


GRAPH NO. 1
DOMESTIC SERVICE
AVERAGE MONTHLY CONSUMPTION
CITIES 10,000 & OVER
ALL MUNICIPALITIES
TOWNS 2,000 & OVER
VILLAGES UNDER 2,000
KILOWATT HOURS
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1914 15 16 17 18 19 1920 21 22 23 24 25 26 27 28 29 1930 31 32 33 34 35 36 37 38 39


GRAPH NO. 5
COMMERCIAL SERVICE
AVERAGE COST PER KW-HR.
CENTS
10
9
8
7
6
5
4
3
2
1
0
VILLAGES UNDER 2,000
TOWNS 2,000 & OVER
ALL MUNICIPALITIES
CITIES 10,000 & OVER
1914 15 16 17 18 19 1920 21 22 23 24 25 26 27 28 29 1930 31 32 33 34 35 36 37 38 39


GRAPH NO. 6
COMMERCIAL SERVICE
AVERAGE MONTHLY BILLS
DOLLARS
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
CITIES 10,000 & OVER
ALL MUNICIPALITIES
TOWNS 2,000 & OVER
VILLAGES UNDER 2,000
1914 15 16 17 18 19 1920 21 22 23 24 25 26 27 28 29 1930 31 32 33 34 35 36 37 38 39


GRAPH NO. 7
COMMERCIAL SERVICE
AVERAGE MONTHLY CONSUMPTION
KILOWATTHOURS
1,000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
CITIES 10,000 & OVER
ALL MUNICIPALITIES
TOWNS 2,000 & OVER
VILLAGES UNDER 2,000
1914 15 16 17 18 19 1920 21 22 23 24 25 26 27 28 29 1930 31 32 33 34 35 36 37 38 39

The Use of Electrical Appliances in Ontario

Results of Surveys of Number of Appliances in Use in Hydro Municipalities and Rural Power Districts

SUBMITTED herewith are tables showing the results of surveys made in Hydro municipalities and in Hydro rural power districts and giving the estimated number of electrical appliances in use by urban and rural consumers at the end of 1939, as follows:

Table No. 1.—Estimated number and per cent of saturation of major electrical appliances in use by domestic consumers in urban municipalities.

Table No. 2—Comparison by systems of saturation of major electrical appliances in use by domestic consumers in urban municipalities.

Table No. 3—Estimated number by systems of major electrical appliances in use among hamlet consumers in rural power districts.

Table No. 4—Estimated number by systems of major electrical appliances in use among farm rural consumers.

Table No. 5—Comparison of per cent of saturation of appliances in use in homes of urban and rural consumers.

Each year all Hydro municipalities and rural power districts are asked to submit a report showing the number of appliances in use. In the municipalities the managers in some cases make a complete check and in others only a spot check, in order to complete this report. In the rural districts the superintendents are sup-

TABLE NO. 1

TABLE SHOWING ESTIMATED NUMBER OF MAJOR ELECTRICAL APPLIANCES IN USE AMONG DOMESTIC CONSUMERS AT END OF 1939 IN URBAN MUNICIPALITIES

Appliances	Number	Saturation
ELECTRIC		
Ranges	159,179	30.5
Hot plates	91,326	17.5
Washers	253,509	48.6
Vacuum cleaners	174,240	33.4
Water heaters (flat rate)	57,426	11.0
Water heaters (metered)	56,104	10.7
Grates	37,814	7.2
Air heaters	148,961	28.5
Ironing machines	15,056	2.9
Irons	479,785	91.9
Refrigerators	104,643	20.1
Toasters	312,905	60.0
Grills	52,170	10.0
Furnace blowers and oil burners	32,044	6.1
Air conditioners	5,361	1.0
Radios	406,456	77.9
Number of Consumers	521,838	

TABLE NO. 2

TABLE SHOWING COMPARISON OF SATURATION OF MAJOR ELECTRICAL APPLIANCES IN USE BY DOMESTIC CONSUMERS IN URBAN MUNICIPALITIES AT THE END OF 1939 IN EACH SYSTEM.

Appliances	All Systems	Niagara System	Georgian Bay System	Eastern System	Northern Systems
ELECTRIC					
Ranges	30.5	30.1	19.4	33.9	41.2
Hot plates	17.5	14.8	33.9	21.5	36.2
Washers	48.6	50.7	47.1	37.5	42.3
Vacuum cleaners	33.4	36.1	21.1	22.3	30.9
Water heaters (flat rate)	11.0	11.6	4.8	9.1	12.4
Water heaters (metered)	10.7	9.5	7.1	17.4	18.9
Grates	7.2	8.3	1.6	4.3	3.8
Air heaters	28.5	29.9	15.6	26.6	25.2
Ironing machines	2.9	3.2	1.8	2.0	1.8
Irons	91.9	92.2	87.4	90.9	96.7
Refrigerators	20.1	22.0	14.3	12.9	12.1
Toasters	60.0	58.9	61.2	63.0	69.9
Grills	10.0	7.5	10.7	19.9	26.7
Furnace blowers and oil burners	6.1	6.8	3.6	4.5	2.0
Air conditioners	1.0	1.1	0.4	0.9	1.3
Radios	77.9	78.9	77.5	70.3	81.2

NOTE: Nipissing System and Sudbury are now included in Northern Systems. They had previously been included in Eastern System.

plied with a card record on which the consumers' appliances are noted.

Reports were not received from a small percentage of the municipalities and rural districts. However, estimates were compiled based on the reports received of the number of appliances in use among all Hydro consumers in Ontario.

Table No. 1 shows that in some cases appliances in municipalities have reached a fairly dense saturation, such as irons 91.9 per cent and radios 77.9 per cent. Others leave considerable opportunity for educational and promotional activities such as ranges 30.5 per cent, washers 48.6 per cent, refrigerators 20.1 per cent.

Table No. 2 indicates the difference in saturation points of the various appliances in different parts of the Province.

Table No. 3 gives data for rural hamlet consumers. These are consumers living in small hamlets and villages included in the rural power districts operated by the Commission. The saturation of appliances in use among hamlet consumers is low in all cases. Their buying power, no doubt, is small, but also educational and sales efforts have not reached these

TABLE NO. 3

Table showing estimated number of major Electrical Appliances in use among Hamlet consumers in Rural Power Districts at end of 1939 by Systems

	ALL SYSTEMS		NIAGARA SYSTEM		NORTHERN AND GEORGIAN BAY SYSTEM		EASTERN SYSTEM	
	No. of Appliances	Per Cent of Saturation	No. of Appliances	Per Cent of Saturation	No. of Appliances	Per Cent of Saturation	No. of Appliances	Per Cent of Saturation
In The Barn								
Electric								
Motor	1,926	3.8	1,442	4.5	103	1.5	381	3.4
Pump	546	1.1	427	1.3	35	0.5	84	0.7
Grain grinder	7	....	7	....	....	....	....	....
Milking machine	4	....	....	....	2	....	2	....
Milk cooler	5	....	5	....	....	....	....	....
Cream separator	37	....	8	....	7	....	22	0.2
Churn	9	....	6	....	1	....	2	....
Incubator	53	0.1	45	0.1	1	....	7	....
Brooder	55	0.1	42	0.1	1	....	12	0.1
Hot bed	14	....	7	....	2	....	5	....
Water heater f.r.	2	....	....	....	2	....	....	....
Water heater met	2	....	2	....	....	....	....	....
Miscellaneous	463	0.9	436	1.4	14	....	13	0.1
In The Home								
Electric								
Range	6,250	12.5	4,391	13.7	709	10.5	1,150	10.1
Hot plate	12,013	23.9	6,455	20.1	2,452	36.2	3,106	27.4
Washer	23,030	45.9	15,872	49.5	2,414	35.7	4,744	41.8
Vacuum cleaner	7,788	15.5	5,376	16.8	852	12.6	1,560	13.7
Water heater f.r.	1,683	3.3	1,410	4.4	76	1.1	197	1.7
Water heater met	917	1.8	698	2.2	57	0.8	162	1.4
Grate	405	0.8	242	0.7	45	0.7	118	1.1
Port. air heater	3,729	7.4	2,342	7.3	310	4.6	1,077	9.5
Ironer	705	1.4	404	1.3	136	2.0	165	1.4
Hand irons	33,476	66.8	24,180	75.5	1,207	17.8	8,089	71.3
Refrigerator	7,178	14.3	4,919	15.4	815	12.0	1,444	12.7
Toaster	24,794	49.5	15,657	48.9	3,092	45.7	6,045	53.3
Radio	35,145	70.1	23,108	72.1	4,383	64.8	7,654	67.5
Furnace blower	931	1.8	658	2.1	41	0.6	232	2.0
Pump	6,042	12.0	4,065	12.7	662	9.8	1,315	11.6
Miscellaneous	2,011	4.0	1,811	5.6	116	1.7	84	0.7

TABLE NO. 4

TABLE SHOWING THE ESTIMATED NUMBER OF MAJOR ELECTRICAL APPLIANCES IN USE AMONG FARM CONSUMERS IN RURAL POWER DISTRICTS AT END OF 1939 BY SYSTEMS.

	ALL SYSTEMS		NIAGARA SYSTEM		GEORGIAN BAY AND NORTHERN SYSTEMS		EASTERN SYSTEM	
	No. of Appliances	Per Cent of Saturation	No. of Appliances	Per Cent of Saturation	No. of Appliances	Per Cent of Saturation	No. of Appliances	Per Cent of Saturation
IN THE BARN								
ELECTRIC								
Motor	8,236	15.4	5,782	15.3	910	15.7	1,544	15.6
Pump	7,144	13.4	5,733	15.2	469	8.1	942	9.5
Grain grinder	2,986	5.6	2,214	5.9	469	8.1	303	3.1
Milking machine	1,620	3.0	1,002	2.6	74	1.3	544	5.5
Milk cooler	944	1.8	710	1.9	59	1.0	175	1.8
Cream separator	3,518	6.6	2,247	5.9	346	5.9	925	9.4
Churn	474	0.8	317	0.8	34	0.5	123	1.3
Incubator	621	1.2	440	1.2	56	0.9	125	1.3
Brooder	642	1.2	447	1.2	54	0.9	141	1.4
Hot bed	45	....	31	....	3	....	11	0.1
Water heater f.r.	105	0.2	89	0.2	13	0.2	3	....
Water heater met.	47	....	19	....	11	0.2	17	0.2
Miscellaneous	558	1.0	443	1.2	89	1.5	26	0.3
IN THE HOME								
ELECTRIC								
Range	9,196	17.2	8,088	21.5	340	5.9	768	7.8
Hot plate	11,326	21.2	7,970	21.1	1,278	22.1	2,078	21.1
Washer	31,054	58.2	23,539	62.5	2,810	48.5	4,705	47.7
Vacuum cleaner	7,623	14.3	6,124	16.2	419	7.2	1,080	10.9
Water heater f.r.	2,157	4.0	2,009	5.3	42	0.7	106	1.1
Water heater met.	1,046	1.9	868	2.3	44	0.7	134	1.4
Grate	375	0.7	309	0.8	13	0.2	53	0.5
Port. air heater	4,333	8.1	3,465	9.2	171	2.9	697	7.1
Ironer	608	1.1	419	1.1	54	0.9	135	1.4
Irons	40,181	75.3	30,064	79.8	3,854	66.5	6,263	63.5
Refrigerator	6,528	12.2	5,164	13.7	392	6.8	972	9.8
Toaster	27,342	51.2	20,608	54.7	2,355	40.6	4,379	44.4
Radio	38,315	71.8	28,158	74.7	3,721	64.2	6,436	65.3
Furnace blower	847	1.6	647	1.7	21	0.4	179	1.8
Pump	8,079	15.1	6,547	17.4	461	7.9	1,071	10.8
Miscellaneous	1,536	2.9	1,448	3.8	65	1.1	23	0.2

consumers as they have similar consumers in the cities and towns.

Table No. 4 gives data for rural farm consumers in each system. Here again the saturation of appliances in the home is less than that in towns and cities.

Table No. 5 gives a comparison of the saturation of appliances in the homes of urban, hamlet and farm consumers. Range saturation in rural hamlet and farm homes is very low compared with urban homes. Washing machines and radios are very similar.

The growth in use of appliances among hamlet consumers has barely kept pace with the growth in the number of consumers and would indicate a considerable field for sales effort.

Among rural farm consumers, like the hamlet consumers, the growth has barely kept pace with the growth in the number of consumers.

Since 1924 the growth in the number of appliances in use each year among urban domestic consumers has been gradual and only slightly affected by boom and depression years.

The average consumption in urban homes of Ontario for 1939 was 2,039 kilowatt-hours per year. It is estimated that an average home could easily consume between 8,000 and 10,000 kilowatt-hours per year. It is, therefore, possible to increase the average consumption four times by the greater use of electrical appliances. The absence of waterworks systems in smaller municipalities curtails the use of water heaters. Natural gas and municipal gas plants affect the use of electric ranges.

Notwithstanding these and other deterrents, we are still far from the saturation point for many electrical appliances throughout the Province.

TABLE NO. 5

COMPARISON OF APPLIANCES IN USE IN HOMES OF URBAN AND RURAL CONSUMERS AT END OF 1939.

	Urban % of Saturation	R.P.D. Hamlet % of Saturation	R.P.D. Farm % of Saturation
ELECTRIC			
Ranges	30.5	12.5	17.2
Hot plates	17.5	23.9	21.2
Washing machines	48.6	45.9	58.2
Vacuum cleaners	33.4	15.5	14.3
Water heaters (flat rate)	11.0	3.3	4.0
Water heaters (metered)	10.7	1.8	1.9
Grates	7.2	0.8	0.7
Air heaters	28.5	7.4	8.1
Ironing machines	2.9	1.4	1.1
Irons	91.9	66.8	75.3
Refrigerators	20.1	14.3	12.2
Toasters	60.0	49.5	51.2
Furnace blowers and burners	6.1	1.8	1.6
Radios	77.9	70.1	71.8

Power Transmission by Direct Current

Swiss High-Voltage Line

TO demonstrate the possibilities of high voltage direct-current transmission with the aid of mutators at each end to convert from and to alternating current, Messrs. Brown, Boveri and Co. have been transmitting up to 300 kw. over a distance of 30 km. at a pressure of 50,000 volts. The two ends of the line are the Wettingen hydro-electric power station on the Limmat, near Baden, Switzerland, and Zurich. The a.c. at 6,000 volts, is converted at Wettingen to 50,000 volts d.c., and after transmission to Zurich is converted back to three-phase a.c. at 6,000 volts. Steel tank mutator sets are used for this purpose. The energy is conveyed partly by overhead line and partly by underground cable.

It was necessary to make considerable modifications to the earlier design of mutator to enable it to meet the severe demands made upon it. Special anode bushings have been devised for the high blocking voltages existing between counter anodes. The engineers of Messrs. Brown, Boveri believe that the generation of high d.c. voltages up to 50,000 volts and more in mutators is likely to be of vital importance to the solution of the problem of power transmission over long distances, and that the demonstration system established between Wettingen and Zurich will prove to be a milestone in electrotechnics of similar importance to the famous Lauffener power transmission of 1891, with which the name of C. E. L. Brown is closely associated.

ADVANTAGES

There are a number of technical and commercial advantages in the use of high-voltage d.c. particularly where transmission of large quantities of power over distances of hundreds of miles is in question. The use of d.c. enables inductive voltage drops to be eliminated, and as such drops at high operating voltages attain a figure which is a multiple of the voltage drop due to resistance this is of great importance. Another valuable feature is that the transmission line does not have to carry any reactive load (wattless power). As wattless current generators would have to be used at intervals of about 200 km. on three-phase transmission systems operating over long distances in order to obtain stability, the use of d.c. would enable substantial economies to be effected in this respect.

Where power has to be transmitted over long distances high voltages must be employed in order to attain maximum efficiency, but corona losses place an upper limit of about 400,000 volts on the tension that can be used. Even at consistently lower voltages (220,000 volts and upwards), hollow conductors, which are relatively costly, have to be employed for three-phase

lines because of the corona and skin phenomena which occur at these high tensions with a.c. transmission; but with three-wire d.c. solid conductors of only one-half to one-third the cross section required for an equivalent amount of a.c. can be utilized. This means lighter transmission line towers and a considerable economy in overhead line construction.

Even greater advantages exist in the case of underground transmission, since the line is not affected by charging and magnetizing currents and will carry a larger load than when operating with a.c. The insulation can be lighter, and as heat losses are more readily radiated the cable can be operated with a heavier loading. Two single-core cables with their lead sheaths forming the earthed middle conductor would be used. The manufacture of cables to carry 200,000 volts d.c. is within the present capabilities of cable manufacturers, and the cost should not be more than half that of a.c. cables of similar capacity —it might be reduced to one-third given sufficient demand. This would make it economically possible to place underground many of the lines where overhead construction is now essential because of the high cost of high voltage a.c. cables. Maintenance charges would be less and reliability would be improved by the elimination of lightning troubles. Although opinion is not unanimous on the point, there is probably a majority in support of the view that underground power routes would also be less liable to damage from aerial bombing. The use of cables for crossing navigable waterways, where it is necessary to use high towers if overhead construction is employed, has obvious advantages.

Operation

The mutators developed by Brown, Boveri are capable of operating at a service voltage of 60,000, and it is intended to advance to even higher tensions in a single cylinder, with full confidence that the new problems which will arise can be satisfactorily solved. Operation of the sets at Zurich presents no difficulties. The initial act is the switching in of the d.c./a.c. mutator at the Zurich substation by closing the air-blast high-speed circuit breaker; the a.c./d.c. mutator is then put under voltage by the closing of the breakers at the other end of the line and the tension is raised by means of the grid control until the current reaches the desired value. The set at the power station end can be remote controlled from the Zurich substation. If a short circuit occurs on the transmission line it is cleared by the mutator at the power station end by the action of the grid control, but in the case of a longer transmission line d.c. circuit breakers for independent closing and opening of the converter set would be necessary. Already development work on the lines of using an electronic valve as a high voltage d.c. circuit breaker has given satisfactory results, pointing to the possibility of transmission from a large central generating station to a number of distant distributing points.—*Trade and Engineering.*

THE BULLETIN

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System Loads in July

WITH this issue *The Bulletin* begins a series of monthly reports showing the growth in system loads. These reports have been appearing in newspapers and in technical journals for a considerable time and it was felt that that publicity was sufficient. We realize, however, that possibly some of our readers have not been getting the information through those channels, and we are, therefore, supplementing that service by the publication of the system load summaries each month.

The report shows the system loads as *primary* and *secondary*. Under primary loads are included all loads delivered by the Commission under contracts extending over definite periods of time. Secondary loads are such loads as are delivered under at-will contracts, i.e., power supplied to consumers when the same is not required for primary loads.

System loads for July, 1940, are compared with the corresponding month in 1939. Primary loads as the total of all systems increased 14.7 per cent over July of last year. The June report showed a corresponding increase of 10.3 percent which was due chiefly to 11.3 percent increase in the Niagara system and 13.2 percent in the Northern Ontario Properties. In the July statement it will be noted, however, that each system, excepting Georgian Bay, shows an increase very close to the increase in the total. The Georgian Bay system had a decrease of 3.4 percent in June which has disappeared in July.

The tabulation for the month of July is as follows:

System	Maximum 20-Minute Peak h.p.		Percent Increase
	July, 1940	July, 1939	
Primary Loads			
Niagara	1,107,105	955,094	+15.9
Eastern Ontario	136,973	123,992	+10.5
Georgian Bay	40,168	40,188	0
Thunder Bay	96,247	85,255	+12.9
Northern Ontario Properties	186,401	161,349	+15.5
Total of All Systems	1,566,894	1,365,878	+14.7
Primary and Secondary Loads			
Niagara	1,368,901	1,250,402	+ 9.5
Eastern Ontario	163,099	154,984	+ 5.2
Georgian Bay	40,235	40,188	+ .1
Thunder Bay	100,389	128,365	—21.8
Northern Ontario Properties	215,892	202,234	+ 6.8
Total of All Systems	1,888,516	1,776,173	+ 6.3

Frost Resistant Concrete

By R. B. Young, Testing Engineer, H.E.P.C. of Ontario

THE engineer with an operating company is in a different position than his professional brother who builds a structure and then moves on. Whether his structures are a credit to his skill or otherwise, he has to live with them and if, at times, this has its drawbacks, it also has its advantages for, if so inclined, he has an opportunity to study their behaviour in service, to observe the effects on their performance of differences in materials and workmanship and to learn from them how to avoid mistakes on future work. The writer has had such an opportunity and it is the purpose of this paper to record some of the lessons learned from this experience as they relate to the resistance of concrete to frost action.

Before proceeding to a discussion of the causes of frost action or deterioration as applied to concrete, the meaning of the term should be defined. As commonly understood and here used, frost action is the breakdown of the structure of concrete caused by alternate freezing and thawing. The presence of moisture in the pores of the concrete is necessary thereto and this moisture

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August, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

may enter either by capillary action or pressure. The deterioration usually manifests itself by scaling and ravelling but it may occur without doing either.

Alternate freezing and thawing of concrete is a contributory rather than a fundamental cause for its deterioration. The fact that the temperature of concrete drops below 32 deg. fahr. has no significance in itself, for dry concrete may be frozen and thawed repeatedly with negligible damage. There must be water in its pores before harm can result from freezing and it must be present in such an amount that when it increases in volume as it changes state, the ice formed will more than fill the pores containing it and so will develop disruptive forces.

Fig. 1—Defects in concrete structures are common at corners, edges and tops of lifts. All three types of trouble have occurred here.

One of the first lessons learned from a wide survey of concrete structures, is that only a very small percentage of the immense volume of concrete in service today, has defects of any importance. Even in those concrete structures where there has been extensive deterioration, and they are few, some parts are much more resistant to weathering than others and a great many are in first class condition. Since, in most cases, the same materials are used throughout a single structure, the variable condition of the concrete would seem to indicate differences in its quality that must have been due to variations in its processing or finishing.

Carrying our field observations further and making a careful analy-

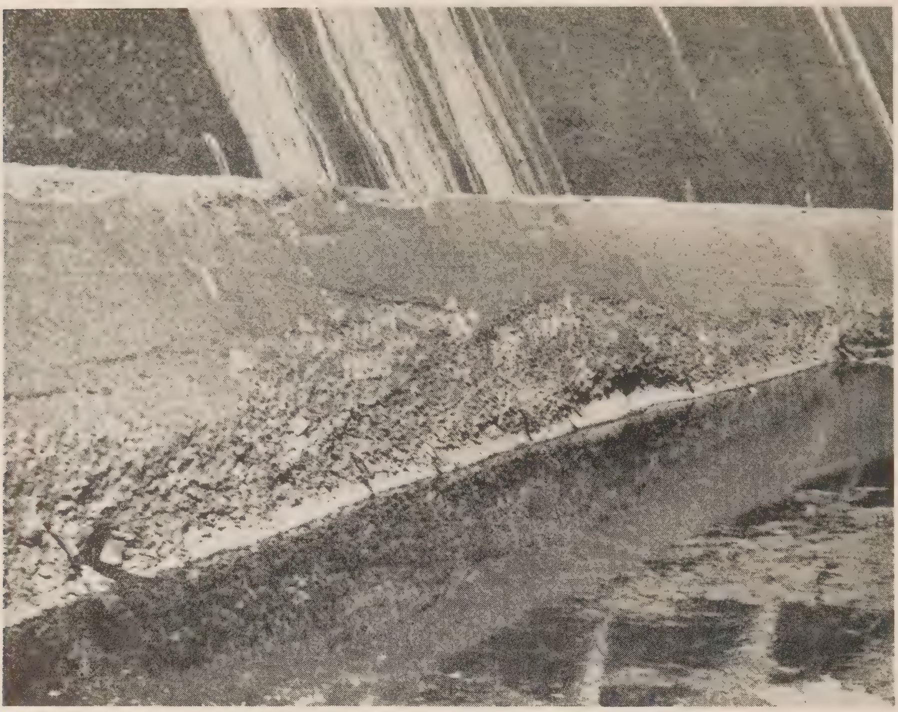


Fig. 2—Segregation resulting from dumping the concrete into the form at one location.

sis of the deteriorated areas found, it soon becomes evident that most of them may be grouped into relatively few types that keep repeating themselves on each of the structures examined. This, in turn, indicates a common or closely related cause for the defects of each type and a study of the conditions surrounding them and their location in the structure suggests their probable cause. The significance of this was discussed at length in an earlier paper by the writer presented before the Institute.* The important conclusion therefrom, which bears on the subject of the present paper, is that the majority of these recurring defects coincide with an excessive porosity of the concrete at the points affected, brought about mainly by segregation.

Segregation may be described as the arch-enemy of concrete. By its very nature, it is a separation of the concrete mix into its component parts. In its grosser forms, the separation may be so complete that honeycomb results; in its lesser, there may be no visible defects, yet the concrete nevertheless is more than ordinarily susceptible to frost deterioration. Any segregation is thus objectionable from the standpoint of concrete durability.

*"Lessons from Concrete Structures in Service" published in the A.C.I. Proceedings 1929, Vol. 25, page 64.

Fig. 3—The dark areas of this concrete while appearing sound have deteriorated due to partial segregation. Note honeycomb in the centre.

The parts of a concrete structure that are particularly liable to deterioration because of segregation, are corners and edges where there is a tendency for mortar to gather, at the tops of lifts where "water gain" may occur and along fill planes and construction joints. The common practice of dumping concrete at one point in a form and pushing it around or letting it find its own way by gravity, is almost sure to cause segregation, especially the latter which results in the formation of both laitance and honeycomb pockets. Honeycomb is frequently found at the bottom of columns, the upper edges of horizontal joints, the underside of floor and deck slabs and even on vertical surfaces, due in most cases, to careless or unskilled methods of placing. One of the worst features of these defects is not the honeycomb itself, which can be easily patched, but the fact that, surrounding each of these areas, is a mass of concrete that appears sound yet which is partially segregated and thus liable to frost attack.

A less recognized type of segregation is caused by overworking. This may be from too much puddling next the forms, which causes a layer of mortar to accumulate there, or it may be due to over-finishing which brings excessive fines and water to the surface. In either case, scaling results.

Scaling is also caused from excessive vibration near surfaces, but more particularly near horizontal surfaces where the segregation that accompanies over-vibration interferes with finishing. The cause of this scaling is apt to be overlooked unless the

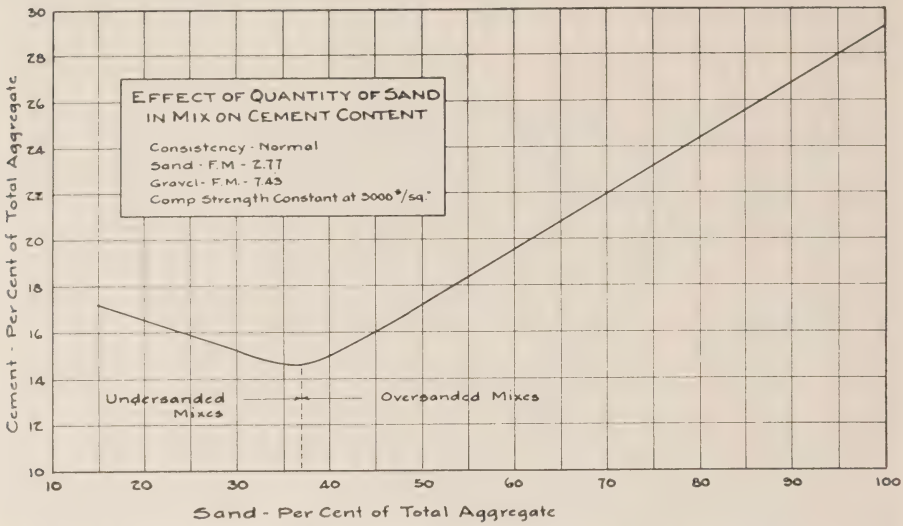


Fig. 4—A typical curve of the effect of sand content in a mix on the amount of cement required to obtain a concrete of given compressive strength and workability.

detailed history of the damaged concrete is known for it cannot be distinguished from scaling caused otherwise.

After segregation, the most common cause of dangerous porosity in concrete, is probably the use of harsh unworkable mixes. A mix that tends to be unworkable is more difficult to handle than one which is not, and hence, is more liable to segregation. In addition, the factors that cause harshness in concrete mixes contribute to make them more than ordinarily porous.

Concrete mixes are harsh for one of several reasons, the most common of which are, first, undersanding or the use of insufficient mortar to carry the size and volume of coarse aggregate used and second, a poorly graded fine aggregate, especially one lacking in the finer portions. This type of trouble is aggravated greatly where the mixes are lean in cement.

Undersanding is a relative term; it depends on the type and grading of the fine and coarse aggregate, the maximum size of the latter and the method to be used in placing the concrete. With the last two factors fixed, there will be, with any combination of aggregates, some ratio of fine to coarse, that will be found to require the minimum amount of cement to achieve a given result in terms of strength and workability. (Fig. 4). Any increase in the quantity of fine aggregate above this minimum ratio, might properly be considered as oversanding and any decrease as undersanding. The terms are thus used in this discussion.

Oversanding of a mix means an increase in the amount of mortar required to obtain a given result; it

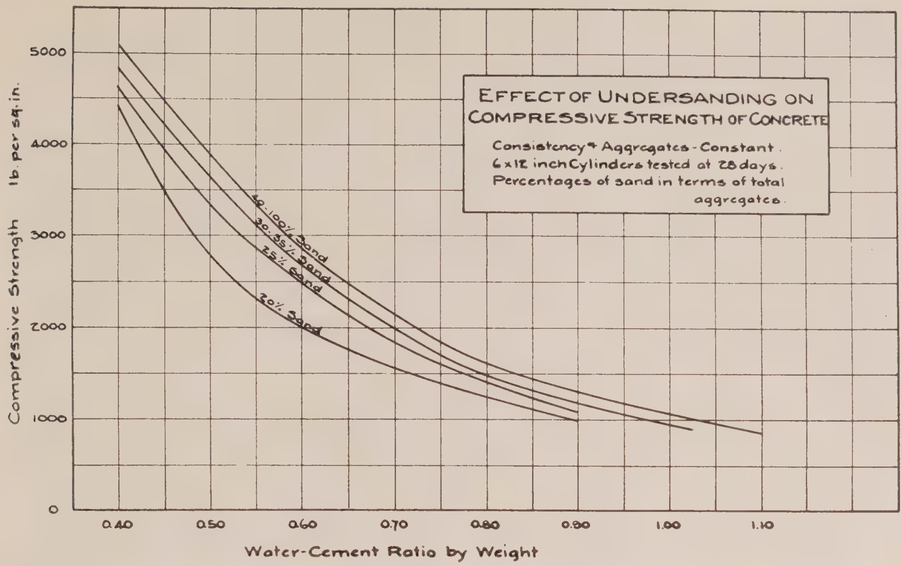


Fig. 5—A set of water-cement ratio curves illustrating the reduction in compressive strength from mixes of increasing harshness which occurs with progressive undersanding.

affects the workability, shrinkage and cement content of the concrete but has little effect on its resistance to frost unless the mortar is itself leaner than about 1:2½ when, with the coarser sands, it is possible to have undesirable porosity by reason of a lack of cement paste. Undersanding, on the other hand, cannot safely be tolerated for, if the sand content is decreased even a little below the optimum ratio, the mix rapidly loses workability. At the same time, the water-cement-ratio-strength curve begins to drop below normal unless means are taken to overcome the harshness of the mix by the method of consolidation. (Fig. 5).

The practical application of these facts to the problem of frost resistant concrete is their bearing on its porosity. Any inherent harshness or lack of workability in the concrete mixes that cannot be overcome easily by the method of deposition used, increases the susceptibility of the concrete to frost action, partly, as already indicated, by its greater tendency to segregation and partly, from lack of a sufficient quantity of fine aggregate to prevent particle interference by the coarse.

The ill effects of undersanding are common in older structures where the use of arbitrary proportions were the rule. A specification that required a mixture such as a 1:2½:5 or a 1:2:4, in which the sand portion formed only one-third of the total aggregate, would, if rigidly enforced, almost always result in an undersanded mix. The usual remedy in such cases was to add more and more water in an attempt to improve its workability.

The results were generally unfortunate. Even today, undersanded concrete is still being produced in quantity, but present practice discourages the use of excess water and vibration provides better compaction, so that fewer examples of defective concrete from this cause may be expected in the future than have occurred in the past.

Harshness in a concrete mixture is influenced by the grading of the fine aggregate used. For equal results, a coarsely graded sand must be used in greater amounts than one finely graded. Where the concretes are produced under a specification that fixes the proportions of the aggregates, the likelihood of undersanding is thus greater with the coarse sand than with the fine. Most present day specifications permit the use of coarsely graded sands with as little as five percent passing the No. 50 sieve, and many engineers and architects even consider them as preferable to better graded materials but they should be used only where exposures are favourable and the proper corrections have been made in the proportions.

After segregation, the next most common source of frost deterioration is defective construction joints and of these, more trouble occurs at horizontal than at vertical joints. The former have apparently presented less difficulty to designers and builders than the latter, and seem to be particularly hard to build so that moisture will not enter. They can be made watertight but, under ordinary job conditions and even with the best intentions on the part of all concerned, a large number of them prove defective in service.

A defective construction joint, whether horizontal or vertical, subjects the surrounding concrete to a particularly severe exposure because of the fact that the moisture movements through it, saturate the concrete adjacent. Thus, even where the concrete next the joint is of good quality, deterioration will occur in time and gradually spread. The writer has watched, year by year, joints in which this was happening, joints where little or no active seepage existed but where the adjacent concrete was slowly deteriorating by reason of repeated freezings and thawings while saturated with moisture sucked from the joint. A great many examples of this sort of trouble are to be seen in such structures as retaining walls, dams, reservoirs and tanks, etc.

Closely related to joints, are cracks that occur in the concrete from one cause and another. The ordinary shrinkage crack, as found in retaining walls and water-impounding structures, is seldom as troublesome, from the standpoint of susceptibility to frost deterioration, as the made joint, possibly because it offers more resistance to the passage of moisture. On the other hand, in pavements and roads, cracks probably cause as much or more frost deterioration than do joints. Besides the common shrinkage crack, there are others that are due to faults of design such as those caused by settlement or other structural movements and insufficient coverage of embedded steel shapes or reinforcement. Given a source of

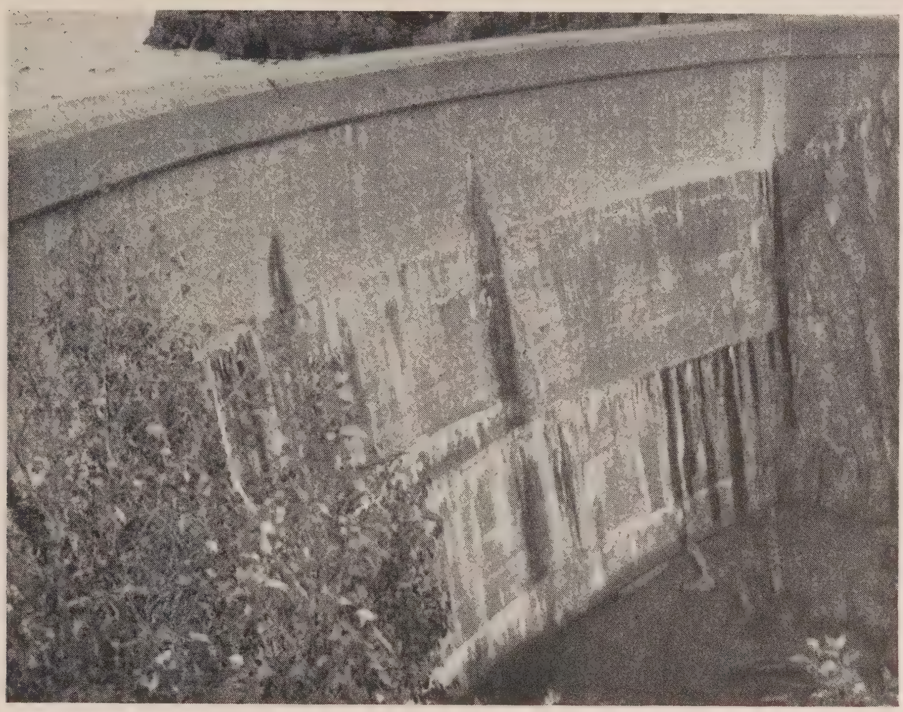


Fig. 6—Defective horizontal construction joints in an otherwise excellent structure.

moisture, the concrete adjacent to cracks will deteriorate similarly to that along joints and from the same causes.

A great deal of frost deterioration is due to lack of provision for the drainage of water that falls on or is collected by a structure in the course of its service. Examples of this type of trouble are everywhere. They may be observed in such places as in arch bridges at the junction of the ribs and piers, on surfaces where the drip from drains impinges or runs down, at the exit of horizontal drains, in ballasted decks of railway bridges, in hollow piers and abutments where the drainage system provided is inadequate or has become inoperative, and behind parapet walls.

Another very common fault, sometimes of design and sometimes of workmanship, is a lack of sufficient slope on horizontal surfaces such as sidewalks, the tops of deck slabs, bridge seats, walls, piers, etc., where little or no provision has been made for draining off the water. No workman, regardless of his skill, can finish a large horizontal surface truly plane; he will leave some depressions, however slight, in which water can collect and stand. It has been the experience of the writer that wherever such spots occur, scaling develops even with concrete other-

Fig. 7—Leakage through a defective horizontal construction joint has deteriorated the concrete adjacent.

wise resistant to frost action. In fact, one is able to predict the location and extent of future scaling from the appearance of horizontal surfaces after being wet.

Other things being equal, frost deterioration will depend on the severity of the exposure to which the concrete is subjected. The severity of exposure can be resolved into two components; one, the degree of saturation to which a concrete is liable when freezing occurs, and two, the probable number of times during the year that the temperature of its exposed faces is likely to drop below 32 deg. fahr. A complete measure of the severity of an exposure is the frequency of the simultaneous occurrence of these two conditions.

The liability to saturation depends on the position of the concrete. A sloping surface such as the downstream face of a gravity dam, will generally retain moisture for longer periods than a vertical surface, and a horizontal surface longer than either. This is especially true where the moisture occurs initially in the form of snow or ice. Angles and pockets remain saturated for longer periods than those parts of the same structure where moisture drains away quickly. Saturation is continuous where the concrete is in direct contact with a source of moisture

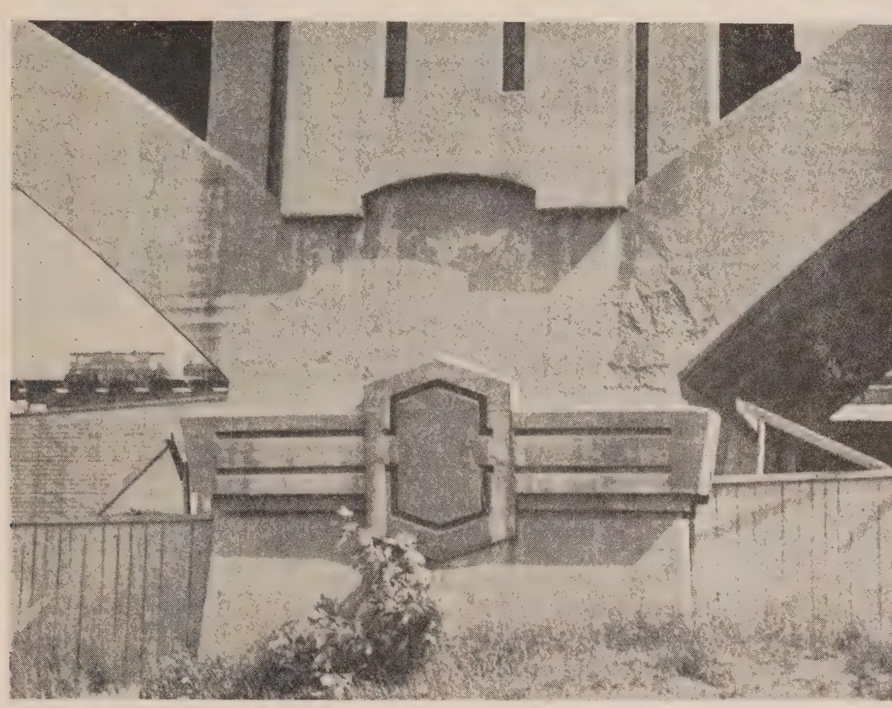


Fig. 8—Deterioration of concrete caused by drainage caught at the junction of arch rib and pier.

such as at the water line of bridge piers and dams or at the ground line of foundations and walls.

The frequency with which the temperature passes downward through the freezing point of water, i.e., on the number of cycles of freezing and thawing, is a matter of climate and location. Thus, frost deterioration is non-existent in the tropics and subtropics except at the higher elevations. As one proceeds northward, frost deterioration will be found even in districts of only occasional frosts, as in the midsouth. In the United States and Canada, frost action is more prevalent and severe on the south and west sides of structures than on the north and east, again a function of the number of cycles of freezing and thawing. It is common experience to find concrete of indifferent quality in first class condition at the water line of a dam on a river flowing south, i.e. the north side, while the downstream or south face is noticeably deteriorated; the reverse will be true on a river flowing north. Some idea of the probable frequency of freezing cycles in any locality may be obtained from a study of the daily mean temperatures compiled by meteorologists. However, these are based on temperatures taken in the shade whereas, in sunny

weather, the exposed surface of concrete may pass one or more times through the freezing point on a day that is recorded as continuously below 32 deg. fahr.

(To be continued)

The Fluorescent Lamp

Its Auxiliary Equipment and Operating Characteristics

By G. F. Mudgett, Manager Illumination Dept., Canadian Westinghouse Co. Ltd., Hamilton, Ontario

THE fluorescent lamp is a low-pressure mercury discharge source. It must be operated with suitable auxiliary equipment. The lamp is designed so that approximately half of the input energy is converted to the ultraviolet line of the mercury spectrum known as the resonance line, 2537 A°*. Most of the remainder is dissipated as heat through conduction, convection and radiation. An important 2 percent appears as the highly efficient blue-green-yellow lines of mercury which add to the light produced by the fluorescence and would give the lamp a characteristic mercury color if no fluorescent powder were used.

The lamp, tubular in shape, contains at each end an electrode in the form of a small coil of wire. These electrodes are coated with a material which has the property of freely emitting electrons when heated. Electrons are necessary to carry the arc current which passes through the vaporized mercury. Since mercury is a liquid at normal temperatures, a slight amount of argon gas is used to facilitate starting. A base is sealed to each end of the lamp.

Fluorescent powders, called "phosphors," are coated on the inside of the bulb by a liquid washing process followed by a heat treatment. It is important that a smooth permanent coating be obtained. This must be even, yet thin, so that the appearance and color of the lamp are satisfactory and there is no excessive absorption of light.

Phosphors are of many types and, therefore, only those most sensitive to the 2537 A° line are used. It is necessary to select compounds which remain stable during the life of the lamp and which can be handled effectively during manufacture. The efficiency of fluorescent lamps varies widely between different colors because the various phosphors used do not reach their peak sensitivity at the same point and consequently do not convert equal amounts of ultraviolet energy into visible light.

This paper was prepared for the Summer Convention of the Association of Municipal Electrical Utilities, which was cancelled due to the war.

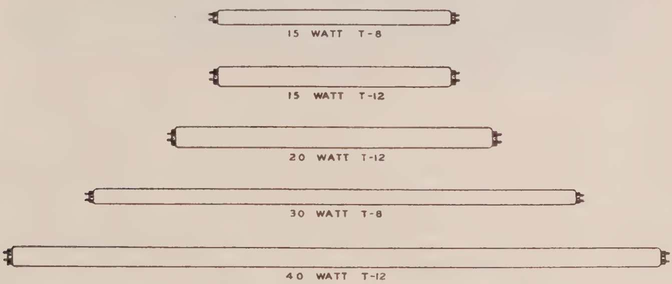
TABLE I

ESSENTIAL TECHNICAL DATA

Standard Westinghouse Mazda F Lamps
(Characteristics Apply to A-C Operation Only)

Watts (Nominal—Lamp Only)	15	15	20	30	40
Bulb	T-8	T-12	T-12	T-8	T-12
Circuit Volts	*	*	*	*	*
Nominal Length	18″	18″	24″	30″	48″
Base	Med. Bi-Pin	Med. Bi-Pin	Med. Bi-Pin	Med. Bi-Pin	Med. Bi-Pin
Lamp Amperes (Approx.)	0.30	0.33	0.35	0.33	0.42
Lamp Volts (Approx.)	56	48	62	103	108
Max. Over-all Length (Including Pins)	17 25/32″	17 25/32″	23 25/32″	35 25/32″	47 25/32″
Rated Avg. Lab. Life (Hours)	2500	2500	2500	2500	2500
Burning Position	Any	Any	Any	Any	Any

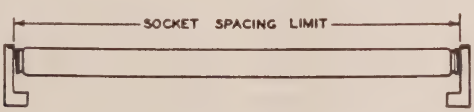
* For operation on regular lighting circuits, standard auxiliary equipment is listed in Table II. With suitably designed equipment, any voltage may be used.



APPROXIMATE INITIAL* LIGHT OUTPUT IN LUMENS

Lamps	Daylight	White	Gold	Red	Blue	Pink	Green
15-Watt T-8	495	585	375	45	315	300	900
15-Watt T-12	495	585	375	45	315	300	900
20-Watt T-12	760	900	540	60	460	440	1300
30-Watt T-8	1230	1440	930	120	780	750	2250
40-Watt T-12	1800	2120					

* At 70% life, average lumen output is reduced about 15%.



LAMP SIZE	15 WATT	20 WATT	30 WATT	40 WATT
MAXIMUM SPACING LIMIT - - - - - - -	17¼″	23¼″	35¼″	47¼″
MINIMUM SPACING LIMIT - - - - - - -	17 1/32″	23 1/32″	35 1/32″	47 1/32″

Among the phosphors used at present are:

Phosphor	*Characteristic Color of Light*
Zinc Silicate	Green
Calcium Tungstate	Blue
Cadmium Borate	Pink
Zinc Beryllium Silicate	Yellowish White
Magnesium Tungstate	Bluish White

All of the above materials are white when not exposed to ultra-violet radiations. Thus, the unlighted appearance of most fluorescent lamps is identical. Exceptions are the gold and red lamps in which it is necessary to coat the bulb with an appropriate pigment and then add a second or inner coat of fluorescent powder (zinc beryllium silicate and cadmium borate, respectively). The pigmented coat absorbs the radiations which are not desired in the spectrum of the finished lamp.

At the present time, five standard sizes of Fluorescent Mazda lamps are

available. General essential technical data are given in Table I. As previously stated, suitable auxiliary equipment must be used for the operation of fluorescent lamps. The bases of the lamp which are of a two-pin design, known as the Medium Bi-Pin, require special lampholders.

A°* is the symbol for Angstrom Unit, a unit of measurement of wave length equal to 1/100,000,000 of a centimeter.

Auxiliary Equipment

It is characteristic of all arc lamps that some method must be provided for limiting the current drawn by the discharge. Without a limiting device, the current would rise to a value that would destroy the lamp. This requirement for fluorescent lamps can best be met by a device or auxiliary not incorporated in the lamp itself. The necessity for an auxiliary permits using that device to gain definite advantages in lamp design and performance.

Auxiliary equipment for the present design of Fluorescent Mazda lamps serves three important functions.

1. Preheats the electrodes to make available a large supply of free electrons.
2. Provides a surge of relatively high potential to start the arc between the electrodes.
3. Prevents the arc current from increasing beyond the limit set for each size of lamp.

Each of these requirements has several ramifications. In general, many electrical circuits and various types of equipment may be used to obtain the necessary results. Two

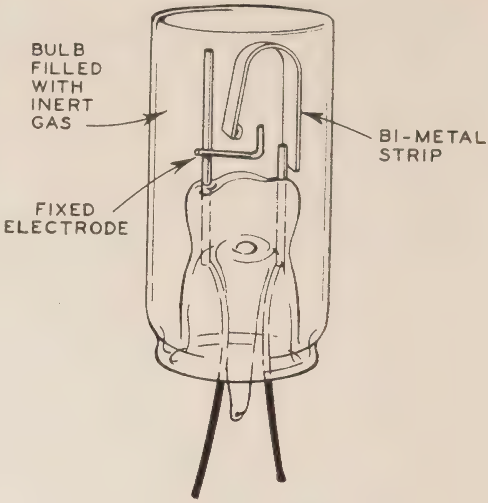


Fig. 1—Fluorescent glow switch.

broadly accepted types of equipment are in use—thermal switch and glow switch equipment. The basic difference between the two is the method of starting the lamp.

For 15 and 20 watt lamps, an open circuit voltage of at least 110 is required; for 30 and 40 watt lamps, the required open circuit voltage is about 190. At these voltages or higher levels, ordinary reactances (chokes) or resistances will provide the necessary current limitations. For distribution systems in the 110-125 volt range, a transformer must be part of the auxiliary equipment for 30 and 40 watt lamps. Usually this transformer and the required reactance for current limitation are combined in one unit.

Glow Switch Equipment

The latest development in starting switches is based on the negative glow discharge principle used in neon indicator lamps. At first, this glow switch merely replaced the thermal

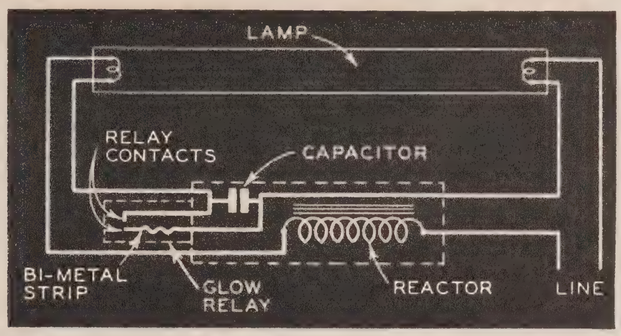


Fig. 2—Fluorescent glow switch control diagram.

switch although it was placed externally on the control case rather than within it. Its development, however, suggested certain other changes so that equipment now widely adopted is designed to separate the various requirements of lamp operation.

The switch is enclosed in a small glass bulb and consists of two electrodes, one of which is made from a bi-metallic strip (Fig. 1). These are separated under normal conditions and form part of a series circuit through the lamp electrodes and the reactance. When voltage is applied, no current flows except as a result of the glow discharge between two electrodes of the switch. A heating results which, by the expansion of the bi-metallic element, causes the electrodes to touch. This short circuiting of the switch, which takes one or two seconds to be completed, allows a substantial flow of current to preheat the lamp electrodes. There is enough residual heat in the switch to keep it closed for about one-half second, a suitable period for the preheating. With the opening of the switch, the resultant high voltage surge starts normal lamp operation. If the lamp arc fails to strike, the cycle is repeated.

The switch does not again glow (if the lamp arc is established) since it is so designed that the remaining available electrical potential is insufficient to cause a breakdown between its electrodes. Thus, it consumes no power and if the lamp is turned out, is available for immediate restarting.

The first application of the glow switch was in the glow relay control which consists of a reactance and a capacitor enclosed in a case with an externally mounted switch (Fig. 2).

Ballasts and Starters

The latest application of the glow switch is designed to separate the switch and capacitor from the reactance. The latter is described as a Fluorescent Lamp Ballast, while the switch and condenser are combined in a Fluorescent Lamp Starter. (Fig. 3).

The starter consists of a glow switch and condenser which are enclosed in a small aluminum container with contacts which may be easily inserted in a bayonet-type

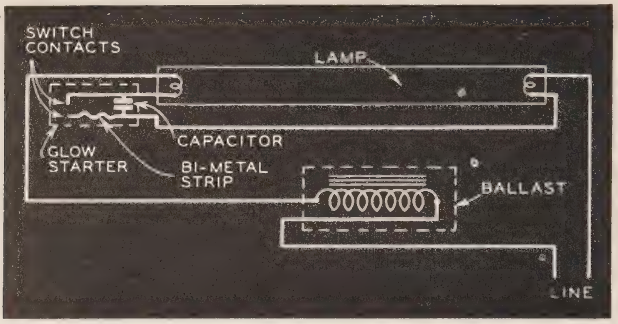


Fig. 3—Fluorescent single-lamp ballast diagram.

adapter socket. This socket may be an integral part of the standard lampholder attached to it by a single screw or merely connected to it electrically. Usually the starter is so placed that it projects through a hole in the lamp reflector and becomes as readily replaceable as the lamp itself. The switch provides the lamp electrode preheating and the starting surge; the condenser suppresses radio interference. Since the switch is designed to operate between critical voltage limits, the proper starter must be used for each particular lamp to insure satisfactory starting. The ballast is a current limiting device consisting of a reactor or high reactance transformer enclosed in a metal case. Since the switch

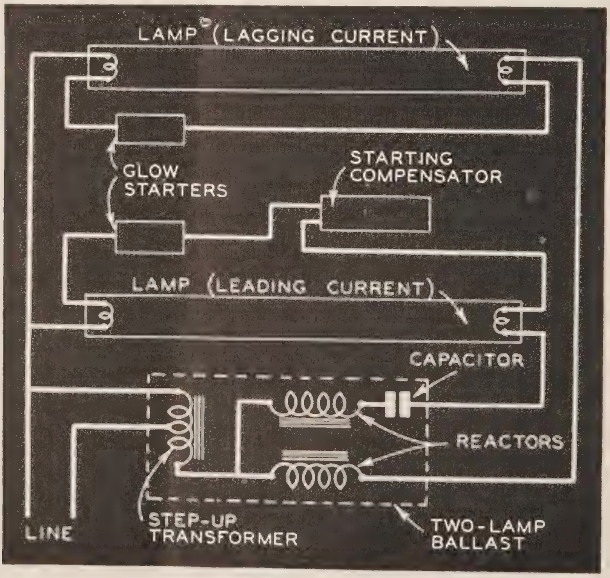


Fig. 4—Fluorescent two-lamp ballast.

has been separated from it, ballasts are considerably smaller than complete control units.

Two Lamp Ballasts

Fig. 4 shows a schematic diagram of a two lamp ballast. Certain practical advantages result from the choice of an electrical circuit which combines under one cover the equipment for the control of two lamps. Chief among the advantages are improved power factor, decreased stroboscopic effect and reduced auxiliary losses. Simplified and therefore cheaper wiring is another advantage.

Each lamp is operated through separate reactors. These reactors are supplied from a common auto-transformer for 30- and 40-watt lamps on 118-volt circuits, but no transformer is required for 15- and 20-watt lamps on 118-volt circuits or 30- and 40-watt lamps on 208- or 236-volt circuits. A capacitor is connected in series with one lamp and its reactor to give "leading" current. The leading and lagging currents will combine with a resulting line power factor of 95 to 99 percent.

The currents in the two lamps will be approximately 115 degrees out of phase. Therefore, the maximum dip in cyclic flicker will occur at different intervals on the cycle and the flicker from the combined light output on the two lamps will be minimized.

Starting Compensator

The starting compensator should be used with all 30- and 40-watt two-lamp ballasts. One compensator is required for each two lamp ballast and it is connected in the starting circuit of the lead lamp, Fig. 4. The compensator functions only while the lamp is starting and is disconnected from the circuit when the glow starter opens.

Operating Characteristics of Lamps and Auxiliaries

Inherently, the fluorescent lamp is different from the incandescent and hence, it is necessary to understand certain characteristics to best judge those fields in which it may be applicable. Obviously, the incandescent lamp has become a basic standard of artificial lighting during the 60 years it has been available and any other light source can best be explained by comparison with it.

The operating characteristics are described in the order listed below:

1. Voltage
2. Frequency
3. Power Factor
4. D-C Operation
5. Stroboscopic Effect
6. Brightness
7. Coolness
8. Color
9. Lamp Life
10. Lumen Maintenance
11. Temperature
12. Radio Interference
13. Noise
14. Vibration

(To be continued)

The Story of the Units

By H. S. Baker, Meter Supervisor, H.E.P.C. of Ontario

MAN has been placed in a universe, the physical aspect of which reaches our perceptions through the agency of the physical trinity *"Length", "Mass", "Time"*.

The scientists of the ages have read with awe and reverence in the book of Mother Nature, of the miracles and laws written therein for them to read concerning the physical trinity *"Length", "Mass", "Time"*.

The inner mechanisms of these three entities are as much beyond our ken as an electric generator is beyond the ken of an ordinary fishworm, hence, we must accept them as beyond our reach and undertake to solve only such attributes as may lie within our ability to observe and comprehend.

We will then assign three arbitrary units with which to measure quantities of these three entities and we will call the units "one centimetre", "one gram", "one second".

> A given length will be L centimetres.
>
> A given mass will be M grams.
>
> A given time will be T seconds.

Now, from the above three *fundamental units*, together with various physical laws which the scientists of the ages have discovered with almost infinite patience and effort, we will develop, step by step, absolute units for the various other physical quantities that we wish to measure.

We will also establish the relative amounts of the above three entities or "dimensions" that enter into each physical quantity. The usefulness of this last operation will not be discussed here but it will illustrate the subservience of all physical quantities to the above fundamental three.

Below are enumerated, in consecutive order, steps by which the units of various physical quantities may be established as based on the fundamental three and upon various physical laws.

The first few steps concern "Absolute Mechanical Units" and we will start with the quantity "Velocity".

VELOCITY

Unit—one centimetre per second.

Quantity—V centimetres per second.

Law—V units equal L centimetres divided by T seconds.

$V = L/T$ and the dimensions are LT^{-1}

ACCELERATION

Unit—one unit of velocity attained in one second.

Quantity—a units of acceleration.

Law—a units of acceleration equal V units of velocity attained in T seconds or

$$a = V/T = LT^{-1}/T = LT^{-2}$$

and the dimensions are LT^{-2}.

FORCE

Unit—one dyne.

Value—the force necessary to produce unit acceleration when applied to unit mass.

Quantity—F dynes.

Law—When F dynes are applied to M grams the resulting acceleration is

a units of acceleration where:—

$$F = Ma = (M)\ (LT^{-2}) = LMT^{-2}$$

WORK

Unit—one erg.

Value—the work done by one dyne acting through one centimetre.

Quantity—W ergs.

Law—When F dynes act through L centimetres, W ergs of work are done or

$$W = FL = (LMT^{-2})\ L = L^2\ MT^{-2}$$

POWER (or rate of working)

Unit—one erg per second.

Value—the rate of working represented by one erg being expended per second.

Quantity—P ergs per second.

Law—When W ergs are expended every T seconds, the power is P ergs per second or

$$P = W/T = L^2\ MT^{-2}/T = L^2\ MT^{-3}$$

There are other absolute mechanical units that are derived in a similar manner but they are not needed in the present step by step development of electrical units.

We will now pass from the Absolute Mechanical Units to the Absolute Electromagnetic Units and then to the Practical Electrical Units.

A fresh start will then be made by passing from the Absolute Mechanical Units to the Absolute Electrostatic Units and comparisons will be made between the Absolute Electromagnetic Units and the Absolute Electrostatic Units of similar quantities measured.

ABSOLUTE ELECTROMAGNETIC UNITS

In this development of the Absolute Elecromagnetic Units, the surrounding medium is assumed to have unity permeability such as vacuum or air.

MAGNETIC POLE STRENGTH

Unit—one unit magnetic pole.

Value—the value is such that when two unit poles are placed one centimetre apart, the resulting magnetic force is one dyne.

Quantity—m units of pole strength.

Law—when two magnetic poles of strength m each, are placed L centimetres apart, the resulting force is F dynes where

$$F = \frac{m^2}{L^2} \text{ or}$$

$$m = L\sqrt{F} = L\sqrt{LMT^{-2}} = L^{3/2}\ M^{1/2}\ T^{-1}$$

CURRENT

Unit—one abampere.

Value—the current which, flowing in one centimetre of a circuit (in one plane) at all points distant one centimetre from a unit magnetic pole in that plane, exerts a force of one dyne upon the pole.

Quantity—I abamperes.

Law—When L_1 centimetres of an electric circuit, at all points distant L_2 centimetres from a magnetic pole of m units strength (all in one plane) carries a current of I abamperes, then the force exerted on the pole is F dynes where:

$$F = \frac{mL_1 I}{L_2^2} \text{ or}$$

$$I = \frac{FL_2^2}{mL_1} = \frac{(LMT^{-2})\ L^2}{(L^{3/2}\ M^{1/2}\ T^{-1})\ L} = L^{1/2}\ M^{1/2}\ T^{-1}$$

QUANTITY OF ELECTRICITY

Unit—one abcoulomb.

Value—when one abampere flows for one second, the total quantity of flow is one abcoulomb.

Quantity—Q abcoulombs.

Law—a current of I abamperes flowing for T seconds discharges Q abcoulombs of electricity or

$Q = IT = (L^{1/2} M^{1/2} T^{-1})\ T = L^{1/2} M^{1/2}$

TOTAL MAGNETIC FLUX

Unit—one magnetic line or one maxwell.

Value—the amount of flux that passes through one square centimetre of the surface of a sphere of one centimetre radius when a unit magnetic pole is placed at its centre.

Quantity—ø magnetic lines.

Law—when a magnetic pole of m units strength is placed at the centre of a sphere of L_1 centimetres radius, then the quantity ø of flux passing through L^2_2 square centimetres of the surface is

$$\phi = \frac{mL^2_2}{L^2_1} = \frac{(L^{3/2} M^{1/2} T^{-1}) L^2}{L^2} = L^{3/2} M^{1/2} T^{-1}$$

MAGNETIC FLUX DENSITY

Unit—one magnetic line per square centimetre.

Value — one magnetic line per square centimetre.

Quantity—B lines per square centimetre.

Law—The flux density B is the total flux ø divided by the area L^2 or

$$B = \frac{\phi}{L^2} = \frac{L^{3/2} M^{1/2} T^{-1}}{L^2} = L^{-1/2} M^{1/2} T^{-1}$$

VOLTAGE

Unit—one abvolt.

Value—the voltage generated in a conductor when it is cut by one magnetic line per second.

Quantity—V abvolts.

Law—When ø lines cut a conductor in T seconds the generated voltage is $V = \phi/T = L^{3/2} M^{1/2} T^{-1} / T = L^{3/2} M^{1/2} T^{-2}$

Now that the abampere and abvolt have been defined, the abohm, abwatt, abfarad, abhenry follow quite simply.

Since the Absolute Electromagnetic Units are too small or too large for convenient practical use, a system of *Practical Electrical Units* has been internationally agreed upon, each of which is some power of ten times the corresponding *Absolute Electromagnetic Unit.*

The following table gives the relations between *Practical Electrical Units* and *Absolute Electromagnetic Units.*

Practical	*Absolute Electro-magnetic*	
One ampere	equals 10^{-1}	abamperes
One volt	equals 10^{8}	abvolts
One watt	equals 10^{7}	abwatts
One joule	equals 10^{7}	ergs
One ohm	equals 10^{9}	abohms
One coulomb	equals 10^{-1}	abcoulombs
One farad	equals 10^{-8}	abfarads
One microfarad	equals 10^{-15}	abfarads
One henry	equals 10^{9}	abhenrys

Absolute electrical units can be derived from the centimetre, gram and second fundamentals by a second method which is just as logical as the first.

The second system is called the *Absolute Electrostatic System* and the values are widely different from the first. The dimensions will, for the present, also appear very different from the first, even though representing the same quantities. The difference in values and dimensions are touched upon below and suggest some great physical law. This second system starts off with a study of electrostatic charges instead of magnetic poles as before.

ABSOLUTE ELECTROSTATIC UNITS

The surrounding medium, in this study, is assumed to have unity dielectric constant such as vacuum or air.

QUANTITY OF ELECTRICITY

Unit—one statcoulomb.

Value—the value of static charge which, if placed one centimetre from a similar charge exerts on it a force of one dyne.

Quantity—Q statcoulombs.

Law—when two charges of Q statcoulombs are place L centimetres apart the force exerted is F dynes where

$$F = \frac{Q^2}{L^2} \text{ or}$$

$$Q = L\sqrt{F} = L\sqrt{LMT^{-2}} = L^{3/2}\ M^{1/2}\ T^{-1}$$

CURRENT

Unit—one statampere.

Value—the value of current which discharges one statcoulomb per second.

Quantity—I statamperes.

Law—When Q statcoulombs are discharged in T seconds, the current is I statamperes where

$I = Q/T = L^{3/2}\,M^{1/2}\,T^{-1}/T = L^{3/2}\,M^{1/2}\,T^{-2}$

VOLTAGE

Unit—one statvolt.

Value—the voltage difference between a point infinitely removed from one unit static charge and a point one centimetre from that charge.

Quantity—V statvolts.

Law—The statvoltage V at a point L centimetres from a charge

Q is $Q/L = L^{3/2}\,M^{1/2}\,T^{-1}/L = L^{1/2}\,M^{1/2}\,T^{-1}$

Now that statamperes and statvolts are defined the other quantities follow quite simply.

COMPARISON OF ABSOLUTE MAGNETIC AND STATIC UNITS

If we divide the dimensions of electrostatic current ($L^{3/2}\ M^{1/2}\ T^{-2}$) by the dimensions of electromagnetic current ($L^{1/2}\,M^{1/2}\,T^{-1}$) we get L/T which is a velocity, and measurements show that it is the velocity of light being 3×10^{10} centimetres per second or 186,000 miles per second.

We will call this great natural unit of velocity V_L which ties together two members of the fundamental trinity of entities, "Length" and "Time".

Einstein has shown that "Mass" is also tied in to this velocity, in that when a moving mass has attained the velocity of light, its mass has dwindled to zero and in place of mass, a definite quantity of energy appears. If you divide energy ($L^2\,MT^{-2}$) by mass M you get $L^2\,T^{-2}$ which is the square of a velocity.

Experimental checks on this statement of Einstein are found in a study of the curvature of the paths of material particles which travel at velocities that are sensible fractions of the velocity of light, as in X-ray tubes.

Einstein's "Theory of Relativity" consists in the modification of orthodox physical mathematics and physical laws in such a way that they not only will fit physical facts for material travelling at velocities with which we are familiar but will also fit physical facts for material travelling at velocities comparable with that of light.

If we set up a row of unit static charges, one centimetre apart and cause them to follow each other at the velocity of light, we have an electromagnetic current of one abampere, or 10 amperes. This illustrates the fact

that a moving static charge develops definite magnetic effects depending on its velocity.

The phenomenon of light consists of electromagnetic and electrostatic oscillations travelling along at the velocity V_L. The motions of the static charges give rise to magnetic oscillations which in turn cause cuttings of lines and hence, voltage oscillation, causing, in turn, further static oscillations of charges.

Below is a table giving the relations between electromagnetic and electrostatic units for the same quantities.
$V_L = 3 \times 10^{10}$ centimetres per second.

Electromagnetic		*Electrostatic*
One abohm	equals V_L^{-2}	statohms
One abvolt	equals V_L^{-1}	statvolts
One abampere	equals V_L	statamperes
One abcoulomb	equals V_L	statcoulombs
One abfarad	equals V_L^{2}	statfarads
One abhenry	equals V_L^{-2}	stathenrys
One abwatt	equals V_L^{0}	statwatts

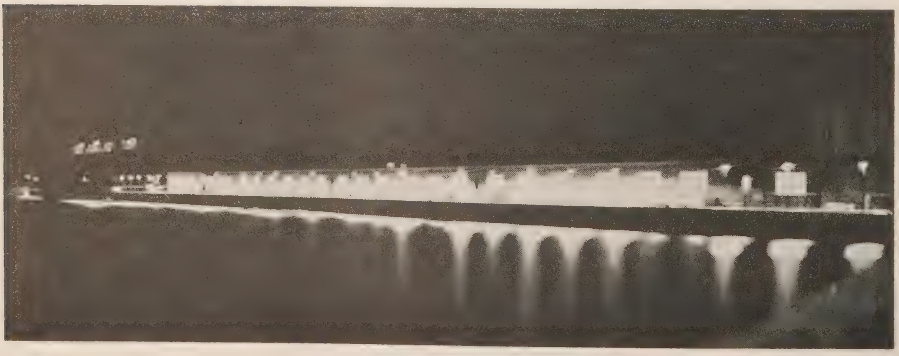
In the above table an evident error appears, in that we say that a current expressed in *Electrostatic units* is equal to a velocity times the same current expressed in *Electromagnetic units.*

In deriving the dimensions of the electromagnetic units we started with a medium having unity permeability and took its dimensions as unity. Similarly, in the electrostatic units we took the dielectric constant of the medium as having unity dimensions.

Had we taken the dimensions of permeability μ as L^{-2} and that of the dielectric constant K as T^2, or had we taken μ as T^2 and K as L^{-2} then the dimensions of any quantity in Electromagnetic and Electrostatic units would be alike as they should be, and the relations between the magnetic and static units would be pure numbers and would be power of (3×10^{10}).

Since the dimensions of μ and K in terms of L, M and T are unknown, it is necessary (as shown in the handbooks) to state the complete expression for a given quantity in two different ways, one containing L, M, T and μ and the other containing L, M, T and K.

They would become alike if the correct dimensions of μ and K were known and substituted in the complete expressions as given.



Training—A Leader's Job

By E. J. Kreh, Manager, Accident Prevention, Philadelphia Company and Subsidiary Companies, Pittsburgh, Pa.

AS one interested in accident prevention, I should like to say at the outset that I regard effective training as the first essential of the safety program. In fact, safety is the direct result of capable leadership and skilled workmanship.

Regardless of the capacity of the safety director or the soundness of his program, I do not believe you can reduce accidents without competent supervision. I contend that no progress can be made without some training, supervision, or other means of control, even though it be poor. Further, the quality and extent of the leadership will determine the ultimate results.

These convictions have been crystallized by my experience of more than thirty years in handling accidents. During that time I have seen startling and repeated evidence that leadership which directs the acts of men so that they function properly is the major factor in accident prevention.

I should like to submit the evidence on which I base these conclusions:

FACT NO. 1

Groups with concentrated supervision have a lower accident rate than groups controlled by limited or thinly-spread supervision. The correctness of this theory is substantiated by the records of the National Safety Council. The first ten industrial enterprises with the lowest accident frequency rates in 1939 are: tobacco, cement, printing and publishing, steel, laundry, automobile, chemical, machinery, glass and rubber. All of these operations are carried on under direct supervision.

In contrast, a number of industrial groups in which supervision is limited or less concentrated are to be found with higher accident rates. True, some closely supervised industries also have high accident rates, but I consider it significant that public utilities, petroleum, transit, marine, construction, mining and lumbering—all industries in which the workman is not constantly under the watchful eye of the foreman—are among the leaders in accidents.

Some may be inclined to challenge these obvious conclusions on the basis that some of these industries are more hazardous. This may be true in some respects, but I submit that transit is not more hazardous than steel, nor public utility work more hazardous than the manufacture of glass, automobiles, or heavy machinery. Thirty years ago, steel had an accident rate as high as mining, yet today it ranks fourth on the list. Is this not evidence that concentrated supervision, with the training and man-building facilities it provides, is an important factor in accident prevention?

Abstract of an address before the Pennsylvania Electric Association.

If you do not agree, try the experiment in your own company. You will find, I am sure, that groups with limited supervision have a higher accident rate than groups with concentrated supervision regardless of the hazard index. For example, customer contact men, such as meter readers and collectors, who work without constant supervision, will be found to have a higher accident rate than the man on the pole, the repairman in the power station, or the electric mechanic in the substation. In my own company, this group has an accident rate substantially higher than the operating group with greater hazard. One conclusion is obvious: Leadership, the training it provides, and the pressure it creates are the predominating influences.

Fact No. 2

Groups with limited, or even sub-standard supervision have lower accident rates than wholly unsupervised or uncontrolled groups. Some of the most striking comparisons are:

Deaths off the job exceed those at work. The National Safety Council is authority for the statement that while 15,500 gainfully employed persons lost their lives through occupational accidents during the year 1939, 25,000 gainfully employed persons met their death in accidents after the whistle blew. Some companies find ratios ranging as high as 6 to 1.

The home accident rate compared with the industrial accident rate is another outstanding example. In 1938, the ratio of home accidents to industrial accidents was 2 to 1.

Despite the fact that Allegheny County is the world's center for heavy industry, where its workers are exposed to the hazards of mining and the making of steel, the ratio of public accidents to industrial accidents in the year 1938 was 4 to 1.

Safer Transportation

In the transportation field from 1927 to 1939, the fatal accident rate for commercial trucks decreased 29 per cent; for motor buses, 50 per cent. During the same period, the private passenger car rate increased 18 per cent. Commercial vehicle drivers and all other drivers who work under supervisory control, consistently have lower accident rates than uncontrolled groups.

In the early days of the steam railroad, there were many serious accidents. Railroads were considered notoriously unsafe, and laws were passed prohibiting speeds of more than fifteen miles an hour. To-day, supervisory control and training have made the steel coach the safest place on earth.

Only a few years ago, air travel was considered a dare-devil undertaking. Now it is recognized as a reliable and safe means of transportation. Supervisory control and training did that. In fact, in any field examined, there is positive evidence that competent leadership, training, and the controls they provide are the predominant factors in safety.

Some may contend that many accomplishments in the controlled groups were due to engineering skill rather than the training and development of supervision and employees.

True enough, in some of its mechanical and physical phases, safety is an engineering problem, but even

in that respect the problem resolves itself into one of leadership and training of the engineer so that he will incorporate into his designs consideration for the safety of the human being who is to make use of his creations. Out of every human endeavour, whether it be work, play or leisure, the problem of safety ensues. To my way of thinking, a man will be safe only when he has learned how.

Efficiency Too

As early as 1926, the American Engineering Council, after a survey of almost 14,000 plants engaged in manufacturing varied types of products from boots to steel, concluded that management, and that means training and control of the behaviour of men, had a direct bearing upon efficiency and accidents. The data they collected from all of these companies consistently showed that those plants which had the highest production performance also had the lowest accident rates; that there was a close relationship between safety and production; a relationship so pronounced and consistent throughout as to indicate a fundamental of management which they stated as follows:

Maximum productivity is dependent upon the reduction of accidents to an irreducible minimum.

Injury accidents are usually the only mistakes which are recorded. The same faults, whether they be in leadership or in men, which produce other losses, are not recorded. If the same faults produce two identical evils, then it follows that by measuring the known factor, you can determine the value of the unknown. Thus the accident rate can and is used as a reliable measure of the competency of supervision, and the reliability of men. It was plainly evident from this survey that if management desired maximum productivity, it must reduce human failures to a minimum. By doing this, they would cure both evils.

A review of the historical background of the safety movement brings further evidence that real progress was not obtained until there was recognition of the value of training and personnel administration.

In the early days of the safety movement, in large measure, employment procedure was more or less haphazard. It was usually the job of the first line supervisor, who had few facilities and little training with which to determine the applicant's capacity or skill. In the absence of medical information, men were hired without knowledge of their physical qualifications. Foremen usually rose from the ranks because of manual skill or seniority. Consideration for leadership qualities and training ability was neglected. Apprenticeship training was haphazard and left without guidance in the hands of older workers; some of doubtful skill who passed on their bad habits and practices to the new employee.

In those days, we had ten to fifteen times as many accidents as we have today, but we did not think they were too numerous at that time. We did issue general warning to be careful, but our safety instructions did not show the men how to be careful. We did erect guards and caution signs, and we did take the indicated action within our knowledge to prevent a recurrence of the accident. We did not,

however, plan as intelligently for safety as we do today, neither did we study our processes to discover the obvious hazards. But above all, we did little training, and what was done was haphazard.

In 1916, the Workmen's Compensation Act, removing the employer's defense at common law, became operative in Pennsylvania. It set up definite schedules for payments which were to be made regardless of fault. The only question involved was whether the employee was injured in the course of his employment. Before enactment of this law, many believed it would add prohibitive cost burdens. This actuated management in all lines of business to search for factual data which would tell them the expected cost burdens based upon their past experience. This review forced many to admit that if the prevailing accident rate would continue, it would impose serious handicaps.

When we were faced with the problem of accident prevention, we knew little about technique. Our first efforts were directed toward the guarding of machinery and the modification of the worker's point of view. Apparently in this endeavour we made many mistakes, because we met stubborn resistance. The workers resented the safety-first signs and slogans. They rebelled when compelled to attend a safety meeting. We had to combat the spirit of bravado which gave applause to the man who took long chances and brought ridicule to the men who took the safe way.

It was some time before we recognized that a large bulk of the accidents were due to bad work habits, ignorance, emotional tenseness, poor judgment, lack of planning and physical incapacity, such as slow reaction, poor vision and other physical defects.

It was not until after the World War that we began to realize that safety was primarily a human problem which rooted deeply into the social life. This realization was forced upon us by another social betterment project, known as industrial relations, which began to take form within industry at that time. It had for its aims correct employment procedure, training and development of supervision, training of men, and medical care — objectives exactly parallel to those involved in safety. It was, therefore, natural that safety should ally itself with that project, for in it were found the procedures required to evolve the safety movement from an emotional creed to a sound man-building program.

I believe that safety would not have reached its present level of accomplishment without the aid of that phase of management which has for its objectives, employee development through:

1. Selection, training, and proper placement of new employee.

2. Retraining, development, and advancement of the old employee.

3. Training and development of supervision to the point where they may become more competent leaders, managers, teachers, and builders of men.

4. Medical care, rehabilitation, or transfer of those found unfit to suitable occupations.

An examination of these objectives

in detail will furnish further proof for my argument.

Training the New Employee

It takes a long time to develop the skill and reliability of the new employee. During the training period, I believe, it will be found that new employees will become involved in accidents more often than experienced workers. At least, that seems to be true in our own group of companies, for when we plotted the frequency curve on the basis of job experience, it showed definite decreasing trends as the experience increased. This was particularly evident in a study we made of a newly hired group of several hundred operators who had been carefully selected and trained for an average of one month before assignment to the job.

Despite this careful selection and training, we found these new men in their first month's service developed an average accident rate approximately five times greater than the average rate of the whole group of older men. It also showed that it took about eighteen months for this group of new men to reach the average performance levels of the older group. While I do not know what the accident rate would have been without care in selection and training, I do not doubt that it would have been many times greater. It was not possible to measure other factors, such as errors in public contact, delays in schedules, or other indirect losses, but it seems reasonable to conclude that these, too, would have been much greater without sound employment and training procedure.

The training period represents a sizeable investment through losses resulting from accident costs and through errors producing waste, breakdowns, and spoilage of products. It therefore seems apparent to me that if we can accelerate the development of the new employee safety and plant efficiency will profit.

Retraining the Older Man

It is well known that many of the older employees are prone to higher frequencies than their fellow workers. This may be due to lack of job skill or bad work habits. Obviously, retraining by skilled teachers should benefit these men. Some companies are, with great success, using the individual's accident record as a means to measure performance, and to isolate those in need of retraining. This procedure presumes, and I believe correctly so, that accidents of manual workers are the only mistakes they make which are recorded. It is therefore probable that the same error which produced the accident had been repeated many times before the injury occurred.

Faulty practices are often acquired by skilled mechanics and taught by them to others. Consequently, it cannot be assumed that an experienced and skilled man will make a good teacher. To insure proper training, some companies have found it practical to analyze the details of repetitive jobs, and to develop standardized, approved procedures before they are taught. In this respect the practice of the American Telephone and Telegraph System is a notable example. In our own company, we have done likewise. For instance, all of

the procedures for taking a boiler or a power line out of service and returning it to service have been detailed and standardized. The prescribed operations include the safety factors involved. These are taught to all employees engaged on that job.

It may not be practical to standardize all job procedures where many varied occupations are involved, but where it can be done, it is a definite step forward in the interest of safety.

Medical Care

Safety men everywhere recognize the difficulty of controlling accidents which are directly due to the physical incapacity of the man. A great many of these accidents are caused through assignment of men to jobs which are beyond their physical capacity. Notable examples are:

Light men for heavy work.

Men with poor vision assigned to a job which requires acute vision.

Men with heart lesions engaged in work in the vicinity of moving machinery.

Men with flat feet and fallen arches on jobs which require a great deal of walking.

Men who are subject to dizziness required to climb.

Through pre-employment examinations, it is possible to hire physically fit men, or through knowledge of their incapacity, it is possible to place them at work which they can perform with safety and normal efficiency. Through periodic examinations, it is possible to transfer or rehabilitate those found physically defective.

It has been found that the accident rate of the group, represented by employees of advanced age, is greater in some respects than the rate of those in middle adult life. It seems reasonable to believe that physical handicap is one of the causes. Periodic physical check-up, followed by transfer, rehabilitation, or retirement, where indicated, should greatly benefit the safety program.

Supervision

Supervision is the keystone in the arch upon which the business structure rests. It is also the keystone in the arch supporting the safety program. If it is weak, the best that is in men lies dormant or dies through lack of leadership nourishment. Without capable leadership, job training is poor or entirely absent. Under such conditions, obvious hazards remain hidden and accidents are numerous.

Without capable leadership, job instructions are inadequate, sometimes missing entirely, and there is no follow-through. Such supervisors fail to recognize that the right to give an order carries with it the obligation to see that it is carried out. They lay the blame for accidents on the workman and fail to recognize their own shortcomings as a factor in the man's failure. They curse the man when he fails to follow instructions instead of searching for the cause for that failure in their own kind of leadership. They believe that their orders must be enforced by threats of discharge or lay-off.

The real leader is capable of guiding and directing his group to bring out the best they have, and in doing so, he has them realize that they benefit by his direction. He possesses qualities which his followers want and can use to their own advantage.

He demonstrates that he understands, appreciates, and sympathizes with their aims and needs. He plans every job. He instructs and follows through to see that his instructions are carried out. He is always busy learning more about the job of his men through contact with others so that he may teach more. His aim is to build men and his greatest satisfaction comes when they advance and progress.

He does not require threats to enforce his instructions. The loyalty he has earned insures obedience to his commands. He is the type of man management is attempting to build through supervisory training courses; a program which does more to insure the success of safety than any other. In this field will be found the training man's biggest and most important job.

If there be any doubt of the importance of the supervisor's place in the accident prevention program, measure the accident performance rates of supervisors engaged in similar enterprise. Wide variations will be found; some groups with perfect accident records and others with high frequencies. If all other conditions are equal, the fault must lie with the supervisor. Conclusive experiments can be made by shifting supervisors. I think it will be found that the good accident rate of any group will always follow the competent leader.

CONCLUSIONS

I hold fast to the theory that safety is first, last, and all the time a natural by-product of competent leadership—a leadership capable of cultivating and using the best that is in men.—*National Safety News.*

"U-235"

USING a mass spectrometer of their own construction, Dr. K. H. Kingdon and Dr. H. C. Pollock of the General Electric Research Laboratory, Schenectady, N.Y., have isolated a minute quantity of the rare form of uranium known as "U-235". It may some day be possible to take from such material several million times the energy to be obtained from burning an equal weight of coal.

On the basis of present knowledge, however, the quantity separation of U-235 from the more common form looks very difficult. Only a hundredth-millionth of a gram, about one thirty-billionth of a pound, of U-235 has been isolated at Schenectady.

"These separation experiments constitute a step toward the goal of tapping the storehouse of energy known to exist in atomic nuclei," explains Dr. Kingdon. "Important progress in this direction was made some years ago when it was discovered that neutrons, nonelectrical particles of matter, even when moving slowly could disintegrate atomic nuclei and release some of the energy contained therein. But much more energy was required to produce the neutrons than was set free by them.

"A possible way out of this difficulty became evident when it was found that the disintegration of uranium when provoked by neutrons, produced other neutrons which might in turn attack other uranium atoms and so produce a chain reaction. This reaction does not take place, however, in naturally occurring uranium.

"Ordinarily uranium is a mixture of three kinds of atoms, weighing respectively about 238, 235 and 234 times as much as a hydrogen atom, and it seemed likely that only one of these kinds was capable of being exploded by slow neutrons. The mass spectrometer offers a means of separating atoms of different masses and, with this instrument, Dr. Pollock and myself were able to separate sufficient quantities of each kind of uranium to determine which one was responsible for the energy release.

"Professor A. O. Nier at the University of Minneosta has prepared similar samples with a mass spectrometer. Both sets of samples were sent to Columbia University where tests with slow neutrons from the cyclotron showed that the U-235 atoms were the ones which exploded.

"It is generally thought that at least a pound of U-235 would be required to make possible the energy-releasing chain reaction. The preparation of such a quantity of U-235 seems quite out of the question with existing mass spectrometers, since the maximum possible yield of these instruments is about one ten-billionth of a pound per hour.

"Other possible methods of separation are being studied and, if from this work a method adapted to quantity production should result, we would have a new kind of energy

source which might have important uses."

The interest in U-235 is based on the fact that when an atom of it is struck by a "slow" neutron, it explodes with the liberation of 200,000,000 electron volts of atomic energy into two other elements and several "fast" neutrons. A typical pair of elements resulting from such an explosion would be barium and krypton. If the fast neutrons can be slowed by hydrogen, as in water, and a sufficient quantity of additional atoms of U-235 provided as targets, it is thought that a chain reaction may be developed. Sufficient U-235, however, has not been separated for a test of this hypothesis. The breaking down of the atom of uranium into the atoms of two other elements constitutes a realization of the ancient alchemist's dream of transmuting one metal into another.

Dr. Kingdon and Dr. Pollock separate U-235, which is found roughly one in 140 parts of common uranium, from uranium tetrachloride. This is vaporized by heating to several hundred degrees in a tiny electric oven. As the vapor comes through a tiny slit it is bombarded by a beam of electrons which makes uranium ions of it. The whole apparatus lies in a magnetic field of suitable strength and, as the voltage accelerating the ions is varied, U-235 and the other varieties of uranium, known to science as isotopes, are collected on platinum plates at the end of a copper tube.

Dr. William D. Coolidge, director of the Research Laboratory, regards identification of U-235 as the isotope responsible for the energy release as an important scientific achievement, but emphasizes the fact that many grave problems must be solved before any practical use can be made of atomic power.

Dr. Kingdon is a graduate of the University of Toronto. He worked on anti-submarine devices for the British Admiralty during the World War. In the General Electric Research Laboratory, he has been associated with Dr. Irving Langmuir in the study of thorium and caesium.—*Electrical Digest.*

Five Accidents in One

The following amusing letter, addressed to an Insurance Company in Ottawa, Ontario, appeared in a recent issue of The Financial Times, Montreal. It is signed by "Can I take it?" and reads:—

"Gentlemen — The soullessness of corporations such as yours is astounding. Let me review my case. I carry an accident policy in your company by the terms of which you agreed to pay me $25.00 a week during such time as I was prevented from working because of an accident.

A week ago I went around on Sunday morning to inspect a new house that is being built for me. I climbed the stairs, or rather the ladder now located where the stairs will be when the house is finished, and on the top floor I found a pile of bricks which were not needed there. Feeling industrious, I decided to remove the

bricks. In the elevator shaft was a rope and pulley, and on one end of the rope was a barrel. I pulled the barrel up to the top floor, and after walking down the ladder, fastened the rope firmly, at the bottom of the shaft. Then I climbed up the ladder again and filled the barrel with bricks. Down the ladder I went again, five storeys, mind you, and untied the rope to let the barrel down. The barrel was heavier than I was, and before I had time to study the proposition, I was going up the shaft with my speed increasing every minute. I thought of letting go of the rope, but before I had decided to do so, I was so high up that it seemed more dangerous to let go than to hang on. So I held on.

Half way up the elevator shaft I met the barrel of bricks coming down. The encounter was brief but spirited. I got the worst of it and continued on my way towards the roof. That is, most of me went on, but my epidermis clung to the barrel and returned to earth. Then I struck the roof at the same time as the barrel struck the cellar. The shock knocked the breath out of me, and the bottom out of the barrel.

Then I was heavier than the empty barrel, and I started down the shaft while the barrel started up. We met in the middle of the journey, and again the barrel uppercut me, pounded on my solar plexus, barked my shins, bruised my body and skinned my face. When we became disentangled I resumed my journey downward and the barrel went higher. Soon I was at the bottom and stopped so suddenly that I lost my remarkable presence of mind and let go of the rope. This released the barrel which had reached the top of the shaft and it fell five storeys and landed squarely on me, and it landed hard, too.

Consider the heartlessness of your company. I sustained five accidents within two minutes. One on my journey up the shaft when I met the barrel of bricks; the second when I touched the roof; the third when I met the empty barrel; the fourth when I struck the bottom; the fifth when the barrel struck me.

Your agent states that it was only one accident, not five, and instead of receiving a payment at the rate of five times $25.00 I am only entitled to one accident at the rate of one alone. I therefore request you to cancel my policy, as I have made up my mind that I will not be skinned either by a barrel or an Insurance Company."—*Distribution of Electricity.*

THE BULLETIN

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E. T. J. Brandon

EDGAR THOMAS JOHN BRANDON, who for over thirty years was Chief Electrical Engineer of The Hydro-Electric Power Commission of Ontario, passed away at his home in Toronto on Monday, September 23, 1940.

Edgar was born in Toronto in 1880 where he received his education, graduating from the Faculty of Applied Science and Engineering of the University of Toronto with the degree of B.A.Sc. in 1902. Soon after graduation he entered the employ of The Ontario Power Company at Niagara Falls, where he stayed until 1905. Following this he went to the Buffalo Pole Line Company at Courtland,

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September, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

N.Y., for a few months. He then went to the firm of W. C. Johnston at Niagara Falls, N.Y., for about a year. Next he spent some time with Sellers and Rippey of Philadelphia and Scranton, Pa., going from there to H. L. Cooper of New York, the Underwriters Engineering Company of New York, and then to Hudson Company of New York. In 1907 he returned to Toronto and joined the City Engineers department, where he stayed until in April, 1908, he came to The Hydro-Electric Power Commission of Ontario, as Electrical Engineer.

It was about this time that the Commission was planning for the actual delivery of power to the co-operating municipalities, so that he had an active part in the planning and construction of the Commission's generating and transformer stations and transmission lines from the very beginning. At the end of 1938, owing to ill health, he was relieved of his departmental duties with the Commission, being retained by the Commission on a consulting basis.

During his leave-of-absence there were times when he seemed to have much improvement of health, and would be a regular attendant at the Commission's office. Lately, however, the condition that was troubling him became more acute, and finally carried him away.

Mr. Brandon is survived by his widow, one son and one daughter, and to these we extend our sympathy in their bereavement.

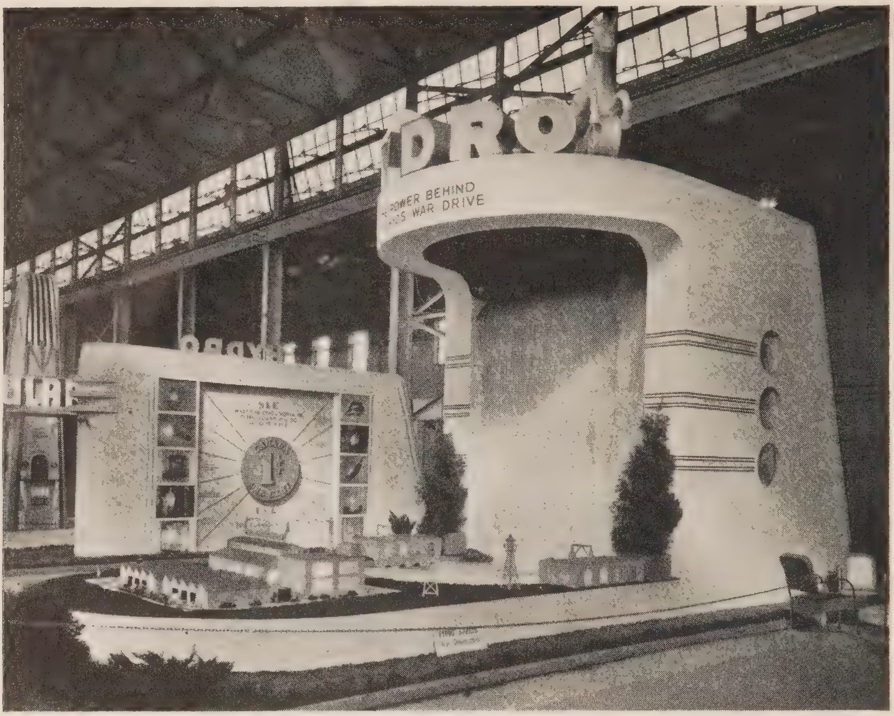
The Hydro Exhibit

THE 1940 Exhibit of The Hydro-Electric Power Commission of Ontario in the Electrical Building at the Canadian National Exhibition was basically the same as in 1939, which the accompanying pictures illustrate. However, in order to place greater emphasis on Hydro's service to industry in helping to maintain and even increase its war effort, some changes were made, particularly in the central section of the display.

Miniature generating stations were set up at the foot of the falls, and transmission towers and power lines erected leading to a group of model war plants in the foreground from whose doors issued aeroplanes, tanks, tractors and other war equipment. To complete the picture a miniature armoured train rumbled its way around a track encircling the plants.

The lights gleaming through the little windows of the factories and power plants, the movements of the train, the water tumbling over the falls and surging from the spillways all lent a general air of activity that caused the passing crowds to stop and investigate.

The illuminated glass map of the distribution system was again used on the face of the eastern wing of the exhibit, but the graphical illustration of rate reductions was replaced by one more readily interpreted by the average person. Representations of



light bulbs and coins, in sizes proportional to the reduction in cost with increasing quantities of power consumed, were used to convey the message of "Cheap Hydro Power."

To add action to the "One Cent Display" on the face of the west wing the large disc representing the coin was made to revolve, which resulted in increased interest in this section.

In advance of the Exhibition suitable literature had been prepared in quantities for general distribution. One item was a blue card about 3 inches by 5 inches tabulating the number of hours various domestic appliances may be operated for one cent's worth of electricity. For example, in the average Ontario home one cent will provide refrigeration for twenty-four hours. These cards received popular acceptance. Another item was a special folder emphasizing Hydro as "Ontario's Vital Public Service to Homes, Farms, Offices and Factories."

Judging both from the increase in questions asked and the greater number seeking information from the attendants in charge, people seemed much more keenly interested in Hydro this year than ever before. It would appear that, once again, a real step had been taken in impressing upon the public the thought of the unbreakable alliance between Hydro and the people of the Province.

Georgian Bay Municipal Electric Association

THE 1940 Annual Meeting of the Municipal Hydro Commissions in the Georgian Bay district was slated to be held at Owen Sound. The Owen Sound Commission and the Executive of the Association chartered the S.S. Keewatin for an all day cruise and the meeting was accordingly held afloat on Georgian Bay on Tuesday, September 10th.

The President, John Kalte of Hanover, as chairman, introduced John McQuaker, Chairman of the Owen Sound Public Utilities Commission, who in the absence of Mayor George Marron, extended a most cordial welcome to the delegates.

Mr. Kalte expressed regrets that the Hydro Chairman, Dr. T. H. Hogg and the Hydro Commissioners were unable to be present. He reported on visits by the Executive of the Association when matters concerning additional sources of power were discussed with Dr. Hogg. The action taken by the Executive in reference to guarding of power stations was also reported by him.

Fitting references were made to the passing of T. J. Hannigan of Guelph, Secretary of the O.M.E.A., and of John Taylor of Hanover, one of the charter members of the Association and a past president of the old Eugenia Electric Association of which he was one of the founders.

Officers elected for the next year are as follows,—

Honorary President
John Kalte, Hanover.

President
Alfred Menary, Grand Valley.

1st Vice-President
R. D. Boyes, Alliston.

2nd Vice-President
R. J. Beaulieu, Penetanguishene.

Secretary-Treasurer
H. S. N. Denef, Hanover.

Directors
Dr. J. Marcus, Kincardine.
C. J. Halliday, Chesley.
G. F. Hutcheson, Huntsville.
P. E. Byrne, Beaverton.
W. Dixon, Arthur.
John McQuaker, Owen Sound.
W. Brown, Meaford.

A committee appointed to deal with the revision of the Annual Fees brought in the recommendation that the charge for fees be $1.25 per 100 horsepower with a minimum of $4.00 per annum under 100 horsepower, and a minimum of $5.00 per annum over 100 horsepower, and a maximum of $20.00 per annum. This recommendation was accepted.

Dr. Wm. J. Chapman of St. Catharines Public Utilities Commission and President of the Ontario Municipal Electric Association outlined a number of matters that should be given consideration, including the licensing of electrical contractors, an agitation to tax public utilities and highway lighting.

R. T. Jeffery, Chief Municipal En-

gineer of The Hydro-Electric Power Commission of Ontario reviewed events of the past year in the Georgian Bay system, and referred to the decision of the Commission to instal a frequency changer set at Hanover and a second generating plant on the Musquash river at Big Eddy. He showed how the Georgian Bay system load had nearly doubled during the past ten years, and that a further increase of 35 to 40 per cent was expected during the next five years. The frequency changer set is necessary to guarantee a sufficient supply of power to the system during the time required to build the Big Eddy plant, and also to assist in the conservation of water for other plants of the system. In addition, the frequency changer would give two sources of supply from the Niagara system, instead of one as at present, which is very desirable.

Although the weather was most unfavorable, everyone agreed that they had had a most enjoyable time. It was decided to hold the meeting at Owen Sound again next year but on an earlier date.

Electrical Pioneering in Canada

UNDER the title "A Look to the North" *Electrical World* has an editorial referring to some details of electrical practice that may be seen by delegates to the A.I.E.E. convention scheduled to be held in Toronto next June, and which it considers as pioneering work on this continent. Some of these practices have been described in former issues of this publication while a few have been developed by The Hydro-Electric Power Commission of Ontario. Such reference gives us a certain feeling of pleasure, and we therefore reproduce the editorial in part as follows,—

> One of the exhilarating things things about electrical practice is that there are usually several good ways of accomplishing any desired objective. Also, as fast as good ways give in to better ones there come new ways to keep progress active. That lends zest to the jobs, but it does, at the same time, raise questions whether there is justification for all the differences between American practice and what is done elsewhere.
>
> Take Canada, for example, and it is a good example because it is nearest to us geographically, technically and temperamentally. Up there they used thermal meters long before we found virtue in them. They use series surge absorbers extensively while we hold to shunt devices. In places they fuse distribution transformers on a loading basis, rather than for fault protection, and claim good results. They apparently followed the European lead on Petersen coils before we got interested. They have been

using single-phase switching for years, and now we see merits in that. Meanwhile, of course, they adopt our advances in other directions. However, they find occasion for reopening questions which we consider reasonably well settled—instance their association program of studying the efficacy of preservative treatments for poles. They have their own answer for conductor vibration troubles.

Service to War Industries

THE Bulletin takes pleasure in publishing a letter from the Chairman to the Hydro utilities, offering engineering assistance to war industries, as follows:—

Dear Sirs:

At present, when every effort is being expended to produce the essential materials required for the defence of the British Empire, it is extremely important that every assistance be given to Industry, and particularly War Industry.

The Hydro-Electric Power Commission wishes to co-operate with your utility in every way possible in rendering such services as we can for the prosecution of these War efforts. Aside from supplying continuous power service, your utility can be of great assistance for National Defence by making sure that all possible is done to ensure that War production is not retarded in any way because of improper application, or lack of use of electrical energy.

It is in this connection that I believe we can be of assistance to you. In our Sales Promotion department we have Power and Lighting engineers, who are well qualified and eager to be of assistance to your industrial customers, in helping them to utilize electrical energy effectively and economically. They are prepared to make plant surveys, free of charge, to see that electricity is used to best advantage. They can give engineering advice and help on problems relating to the application and use of electric power, and can be of assistance in obtaining information on new processes and on new equipment.

I hope you will make this service known to your Industrial customers, and that you will make full use of the facilities which we have to offer you. For further information and assistance, please communicate with Mr. M. J. McHenry, Director of Sales Promotion.

Yours very truly,

(Signed) T. H. HOGG,
Chairman.

Lighting For Industry

By F. G. Reed, Illuminating Engineer, H.E.P.C. of Ontario

WITH the all-out Canadian war effort business is reported to have increased about 20 percent in the first seven months of this year as against the same period in 1939. The stimulus of war orders has made its effect felt only in recent months. In anticipation of the effort still to come active plants have been enlarged and re-equipped, and some that have been practically idle for years are either producing or will be doing so before long.

Considered entirely apart from its "stop Hitler" aspect, the speed-up is being conducted on a sound business basis, with lowered production costs the target of every manager. Purchases of raw materials, whether of man-hours of labor or kilowatt-hours of electricity, are made with an eye to what they can produce. Purchased lighting, for instance, while frequently considered just another item of overhead expense, must be regarded with a view to what it can deliver. If it can make a return on the money put in it then it is something more than mere overhead, it is a good financial investment. It should be planned and installed with that thought in mind.

THE VALUE OF GOOD LIGHTING

From the dollars-and-cents point of view good factory light *is* good business. A number of industrial plants have co-operated in checking to see what improved plant lighting has done for them. The noted advantages may be summarized as follows:

1. Greater accuracy of workmanship, resulting in an improved quality of product with less spoilage and rework.
2. Increased production and decreased costs.
3. Better utilization of floor space.
4. More easily maintained cleanliness and neatness in the plant.
5. Greater ease of seeing, especially among older, experienced employees, thus making them more efficient.
6. Less eyestrain among employees.
7. Improved morale among employees, resulting in decreased labor turnover.
8. Fewer accidents.

The reasons for some of these results are obvious; others have behind them more obscure factors that are only discovered in the science laboratory. When all is said and done it is the results that count; and those that have taken the trouble to check tell us that these are the advantages they have found.

Take Item 1, for instance. Good illumination increases accuracy of workmanship. With articles of precision manufacture good lighting permits a very close visual check throughout the whole process. Slight defects which would otherwise be seen only at the final inspection, and

result in rejection at that time, can be seen as they occur. In this way much time and labor can be saved.

Now take Item 2. An increase in illumination from 1 foot-candle to 20 foot-candles increases the speed of seeing approximately three times. This improvement often occurs upon the installation of a modern lighting system. The increased speed of seeing affects practically everything the workman does. The time he formerly wasted in seeing is available for productive work. Automatically and without conscious effort his work output is increased.

Even where automatic machines are used good lighting is important. It assists operators to easily locate and correct troubles that may be causing low quality production. Some machinery, as in the textile industry, is semi-automatic and operates at constant speed until breakage of the material occurs. The time of shut-down varies from 5 to 30 percent of total time. Good lighting greatly decreases the time required to locate and repair the trouble. This results in measurably increased production. Summing up: a human being is a machine; and all things else being equal, he works best under good lighting but not nearly as well under poor lighting.

Factors in Good Illumination

Quality of Lighting.

So much has been said about foot-candles in modern high-level lighting that many people overlook the matter of *quality*. If quality were given no consideration, you could double the light in your factory without making any improvement in seeing conditions. It would be an extreme case, but it would be possible. Actually it often occurs that a 100 percent addition of light gives from 50 to 75 percent the improvement it should. That is why lighting should be planned to fit the job.

Glare is a factor in quality. It interferes with seeing, cuts employee efficiency, and sometimes creates accident hazards. Reflected glare may be just as objectionable. It results from lighting fixtures of the wrong kind, or in the wrong locations, or both. Reading the graduations on the barrel of a micrometer is one of the tasks made difficult by reflected glare. The proper lighting fixture correctly placed makes seeing much easier.

Diffusion and direction are also factors in quality. The kind of lighting that is good for one job may be the worst sort for another. For instance, a good way to light for tin plate inspection is by means of a large-area low-brightness diffuser located so that the tin plate reflects the lighting fixture. The scratches and unplated spots are seen against the mirrored image of the light source. But if you wish to inspect sheets of roofing material for wrinkles it is best to use a sharp directional light striking the surface obliquely, casting shadows, and revealing surface defects by shadow contrast. Neither of these jobs could be done properly under the lighting that is good for the other; yet they are both commonly done under lighting units that do not give the proper light for either.

Quantity of Light.

Even the best artificial lighting systems supply meagre light compar-

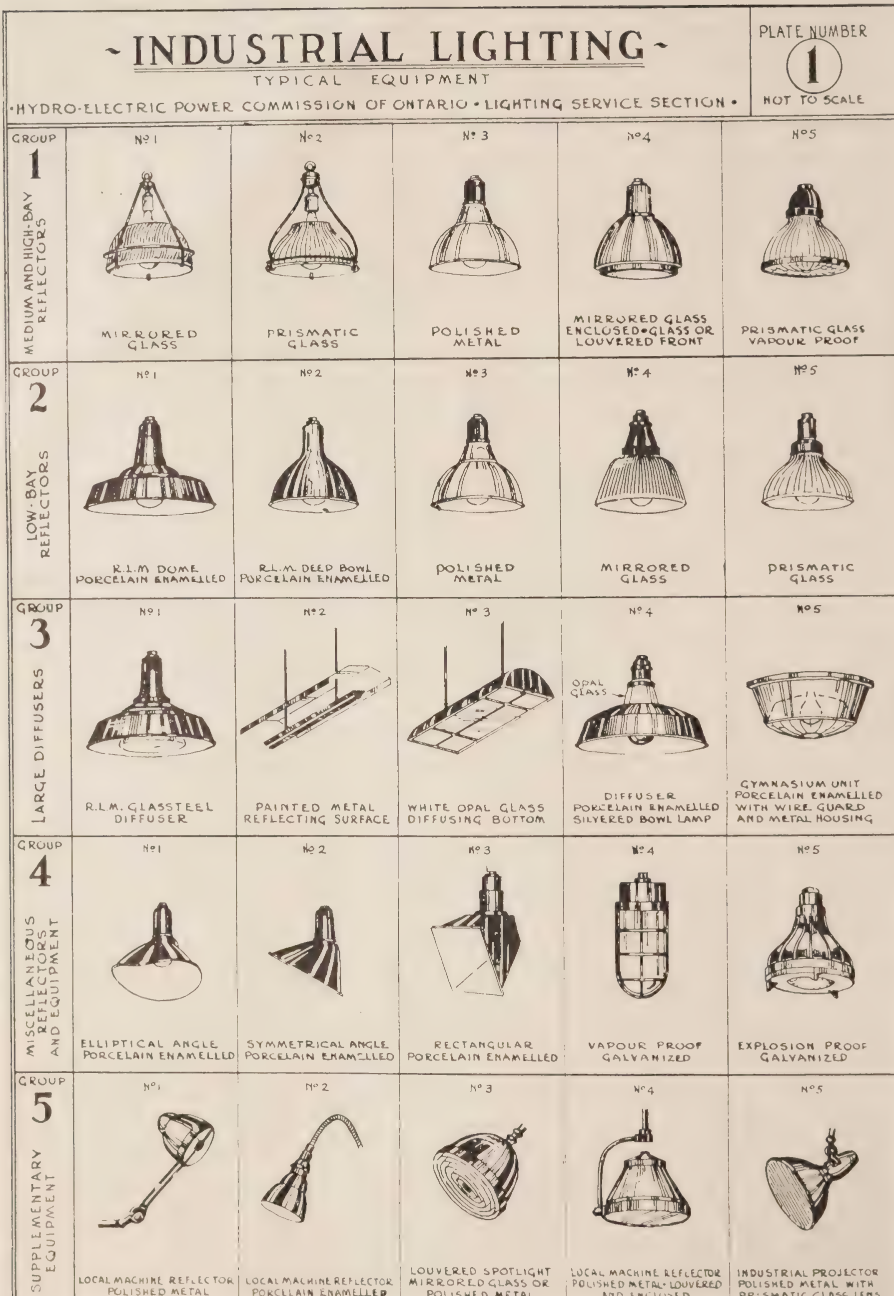

-INDUSTRIAL LIGHTING-
TYPICAL EQUIPMENT
•HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO • LIGHTING SERVICE SECTION •
PLATE NUMBER 1
NOT TO SCALE
GROUP 1 MEDIUM AND HIGH-BAY REFLECTORS
No 1 MIRRORED GLASS
No 2 PRISMATIC GLASS
No 3 POLISHED METAL
No 4 MIRRORED GLASS ENCLOSED•GLASS OR LOUVERED FRONT
No 5 PRISMATIC GLASS VAPOUR PROOF
GROUP 2 LOW-BAY REFLECTORS
No 1 R.L.M. DOME PORCELAIN ENAMELLED
No 2 R.L.M. DEEP BOWL PORCELAIN ENAMELLED
No 3 POLISHED METAL
No 4 MIRRORED GLASS
No 5 PRISMATIC GLASS
GROUP 3 LARGE DIFFUSERS
No 1 R.L.M. GLASSTEEL DIFFUSER
No 2 PAINTED METAL REFLECTING SURFACE
No 3 WHITE OPAL GLASS DIFFUSING BOTTOM
No 4 OPAL GLASS
DIFFUSER PORCELAIN ENAMELLED SILVERED BOWL LAMP
No 5 GYMNASIUM UNIT PORCELAIN ENAMELLED WITH WIRE GUARD AND METAL HOUSING
GROUP 4 MISCELLANEOUS REFLECTORS AND EQUIPMENT
No 1 ELLIPTICAL ANGLE PORCELAIN ENAMELLED
No 2 SYMMETRICAL ANGLE PORCELAIN ENAMELLED
No 3 RECTANGULAR PORCELAIN ENAMELLED
No 4 VAPOUR PROOF GALVANIZED
No 5 EXPLOSION PROOF GALVANIZED
GROUP 5 SUPPLEMENTARY EQUIPMENT
No 1 LOCAL MACHINE REFLECTOR POLISHED METAL
No 2 LOCAL MACHINE REFLECTOR PORCELAIN ENAMELLED
No 3 LOUVERED SPOTLIGHT MIRRORED GLASS OR POLISHED METAL
No 4 LOCAL MACHINE REFLECTOR POLISHED METAL• LOUVERED AND ENCLOSED
No 5 INDUSTRIAL PROJECTOR POLISHED METAL WITH PRISMATIC GLASS LENS

Fig. 1—General lighting with "high bay" reflectors.

ed to that found out of doors. The ideal result (within the limits of economy) is obtainable when a competent lighting specialist, who knows the how and why of lighting, co-operates with the workman who knows what he must see to perform his task.

In order to obtain an improved quality of product with decreased spoilage, fewer accidents, and less wear and tear on the human machine, it is necessary to provide much more light than required for barely seeing. There are in use many installations supplying from 25 to 50 ft-c. of general lighting and some supplementary lighting of from 200 to 250 ft-c. These have been found to be profitable since the benefits derived much more than offset the operating cost.

TYPES OF LIGHTING

General Lighting.

Where there is no sky-light or monitor, and all natural light must come through side windows, very little light penetrates to any distance inside the windows. Even on bright days it drops from a possible 100 ft-c. at the windows to as little as 5 ft-c. 15 feet inside the room. Moreover, approximately one-half the days of the year are dull days, according to Ontario meteorological records. Natural light is therefore not dependable; and unless there is good artificial lighting most of the workers are unfairly penalized.

Figs. 1 and 2 show how well-planned general lighting makes seeing easy all over the plant. The drawings on page 270 illustrate the various types of fixtures that may be used for general lighting. Group 1 is for "high-bay" mounting (30 ft. or over), and Group 2 is for "low-bay" (under 30 ft.). Incidentally, No. 1 of Group 3 is a low-bay fixture which in certain

Fig. 2—General lighting with "low bay" reflectors.

cases is preferred for its quality of lighting. This is the fixture used in the installation shown in Fig. 2. For coarse or medium seeing jobs general lighting such as illustrated in these two photographs is excellent.

Distribution of general lighting should be uniform throughout the work area. This reduces contrast and affects the eyes more favourably than spotty lighting. Besides, it gives maximum utilization of floor space. Machines and benches may be rearranged at any time for more efficient operation without having to consider "whether there is enough light for the job over in that corner". Direct lighting units should be spaced no farther apart than their height above the floor.

Local Lighting.

Seeing tasks of varying degrees of severity are frequently encountered, and for these general lighting is inadequate. It would cost a great deal

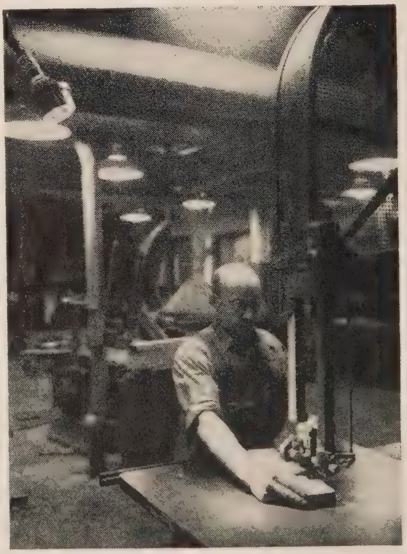


Fig. 3—High intensity lighting plus good general lighting makes seeing easier.

Fig. 4—Large area diffusers for shinymetal parts—buffing.

to raise the all-over lighting level to a point suitable for many fine seeing jobs. Local or supplementary lighting is the answer to these problems. As the name implies, it supplements but *does not displace* general lighting. The latter is quite necessary, otherwise high contrast between lighted and unlighted areas will result, with consequent eyestrain. A good ratio

Fig. 5—Fluorescent lighting in a hosiery mill.

to work to is 8 to 1, or 10 to 1, between local and general lighting intensities.

Fig. 3 illustrates the use of one type of supplementary lighting equipment. Fig. 4 is another. There are five or six types in all. Neither of these fixtures in Figs. 3 and 4 would suit the requirements of the work on which the other is used.

Polished surfaces such as micrometers, scales, etc., require well diffused lighting, best supplied by fixtures like those in Group 3 on page 270, Nos. 2 and 3 in the group. A few other practical uses of large-area diffusers are hand setting of type, imposing stones, tin plate inspection, buffing and inspection of small polished metal parts.

Concentrating supplementary fixtures are illustrated in Group 5. They are used for various types of machines including band-saws, stamping machines, sewing machines, scribing, inspection of sheet materials for wrinkles, and other jobs.

The following are some of the more common seeing tasks for which supplementary lighting of one kind or another is required: all hand-fed machine tools, woodworking, typesetting and imposing, weaving (small looms), sewing for leather and cloth industries, candy-making, engraving, assembly of small parts, automobile pits and lifts, automobile washing, business machines, and inspection of every type of manufactured equipment. Supplementary lighting units

should always be specified and located by a lighting expert.

Fluorescent Lighting

This is a radically different type of light source to those with which most people are familiar. The lamp "bulbs" are long and tubular, and they give off light from a chemical coating on the inner surface of the tube. This coating is caused to "fluoresce" by the action of invisible ultra-violet rays inside the tube.

While this type of light source and the various fixtures in which it is used have not reached their final development, many good applications have already been found. Fig. 5 illustrates its use in a hosiery mill where continuous lines of fluorescent tubes in semi-concentrating reflectors deliver a good level of illumination of excellent quality.

One of the immediate problems in fluorescent lighting is to overcome the flicker effect of 25 cycle current, which makes it impracticable in many cases. This has been partially neutralized, and probably future research and improvements will broaden the field for its use. One of its great advantages (where it can be used) is that it makes possible more ideal levels of illumination at a moderate current cost.

Maintenance of Good Lighting

A lighting system that is good when first installed will soon deteriorate unless properly maintained. The factory owner should establish a regular system of maintenance so that skylights, side windows, lighting fixtures, and lamps are kept clean, in proper adjustment, and in good repair. One way to handle this problem methodically is to check the illumination from time to time with a light meter. When it has decreased to 75 percent of its initial value the equipment should be washed with soap and water. Sometimes group replacements of lamps can be made to coincide with a cleaning period and so save in maintenance cost. Especially in high-bay installations, lamps should all be replaced at one time to ensure constant lighting service from every fixture.

Walls and ceilings should be repainted, preferably in light tones, at regular intervals. With indirect lighting systems the ceilings must be kept white. When planning a new system some depreciation should be allowed for, and the new installation must be better than it is expected to become under average operating conditions.

Halftone cuts courtesy of Canadian General Electric Co., Ltd.; Curtis Lighting of Canada, Ltd.; Amalgamated Electric Corporation Ltd.

Frost Resistant Concrete

By R. B. Young, Testing Engineer, H.E.P.C. of Ontario

(Continued from August.)

Up to now, this paper has dealt entirely with the causes for the deterioration of concrete from frost action but this is not its primary purpose, which is to indicate how frost resistant concrete may be made. However, the former is necessary to a determination of the latter, just as in medicine, diagnosis is necessary before medication. But in medicine, medication is for the purpose of curing sickness, whereas this paper deals with prevention rather than cure, for the subject of the repair of concrete already damaged, has been dealt with at some length by the writer and others in the publications of the Institute, to which those having problems of rehabilitation, are referred.

A frost resistant structure may be said to start with its designer who should, at all times, keep in mind, the question of its exposure and maintenance. For example, he should provide sufficient drains wherever needed, so designed that they will not plug or otherwise become inoperative in use. Pockets where moisture can collect and stand should be guarded against, such as behind parapet walls and where intersecting surfaces form sharp angles. Horizontal surfaces should be provided with sufficient fall so that the inevitable inequalities of finishing will not leave low areas from which water will not drain. If at all avoidable, drains should not be allowed to spill onto concrete surfaces but should be extended so that the drainage will fall free. Other precautions will suggest themselves to the alert designer.

Construction joints should also receive careful consideration. Those that have to perform as contraction joints should be so designed that when fully closed, destructive pressures that might weaken the concrete by overstressing, will not be developed for this makes them more liable to frost attack. Chamfering the edges of joints to avoid pinching is a good way of preventing this sort of trouble. Joints, the purpose of which is solely to divide the structure into convenient units for construction, should be carefully laid out in advance, not left to the whim of the builder. Horizontal joints should be avoided near the ground line of foundations or near the water line of water impounding structures. One way of solving the horizontal joint problem is to eliminate them whereever possible. The organization with which the writer is connected, has done this since 1930 in all retaining walls, gravity dams, sluiceway piers, etc., up to 70 feet in height, casting these in one continuous operation. No difficulty that could not be anticipated by careful planning has been experienced with this method. From the standpoint of appearance and maintenance, the practice has been a complete success.

A primary requisite for frost resistant concrete is impermeability and low absorption, and the technical literature has, for years, contained many excellent articles describing how such concrete may be made. Most authorities recommend for concrete exposed to weathering, a minimum 28-day compressive strength of at least 3,000 p.s.i. and a maximum water-cement ratio of not over 6 to 6½ U.S. gallons of water per sack of cement. In general, these requirements will result in frost resistant concrete, provided materials and workmanship are satisfactory, and while durable concrete may be obtained with lower strengths or more mixing water, any lessening of these standards should be done only after consideration of both the particular materials to be used and the exposure to which the structure will be subjected.

Since the characteristics of the concrete mixture are so important a factor in obtaining frost resistant concrete, care should be taken to see that there is plenty of mortar present to carry the coarse aggregate, and any error should be on the side of oversanding. The sand should contain plenty of fines, at least ten percent passing the No. 50 sieve, preferably more. If, for watertight concrete, a choice has to be made between a sand coarser than this and one approaching the upper limit of fineness allowed by standard specifications, that is 30 percent passing the No. 50 sieve, the writer would favour the latter, in spite of the fact that more cement would be required. Many will not agree with these particular recommendations, and, the writer, knowing this, makes them with some reluctance but he is of the firm opinion, based on no little experience and observation, that they are sound and that much concrete which would otherwise be satisfactory, has scaled and deteriorated because the fine aggregate used in its construction was lacking in essential fines.

It should be remembered also, that some of the fines necessary for good concrete are supplied by the cement. While it may seem to be good economy to use lean mixes, it should be done cautiously and with full knowledge of all the circumstances, for, depending on the size and type of aggregates, and the method of placing, a certain minimum amount of cement is required for purposes of density. It is true that we are learning how to make better concretes with less cement but for the average job it is still a safe rule to avoid lean mixes.

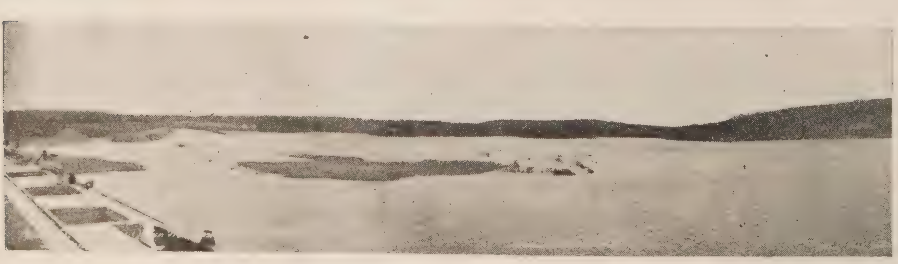
Workmanship is of the first importance in obtaining a frost resistant concrete. Every means should be taken to avoid segregation and all handling and placing equipment should be so chosen and arranged as to avoid, as far as possible, separation of the mortar from the aggregates. Chutes, if permitted at all, should be confined to short lengths for final placing; the handling of concrete in the forms should be kept to a minimum, i.e., it should be placed initially in that part of the form it is intended finally to occupy; vibrators should not be used to move concrete from one part of the form to another; overworking of vertical faces should be guarded against and only enough puddling done to keep

the large aggregate away from the forms. Overfinishing of horizontal surfaces should be avoided, especially where they are to be exposed to the weather; a float finish is, on the average, more resistant to frost than one that has been steel trowelled, not because of anything inherently wrong with the latter but because less skill is required to produce it satisfactorily under average job conditions.

Although not discussed at any length when considering defects commonly giving rise to frost deterioration, the use of excess water is frequently a contributory cause of segregation, particularly to that form known as "water gain", in which water tends to separate from the mix and collect in the top part of sections being cast. Thus the use of overwet mixes is to be avoided as increasing the likelihood of segregation and its attendant evils, and in planning for frost resistant concrete, care should be taken that the means for handling and placing the mixes do not jeopardize its quality by requiring wet consistencies for their successful and economical use.

Finally, skilled and adequate supervision is among the requirements for frost resistant concrete. It should take the form of attention to all of the usual factors considered necessary to good concrete, with particular attention to those features that have been indicated here as being the principal causes for frost deterioration. The supervision will usually be performed by inspectors under the direction of an engineer and it is important that these inspectors be experienced men of good judgment, cognizant of the importance of attention to details. Few good jobs just happen; they will be found to have had expert and detailed supervision, usually by a resident inspector, and anyone desiring frost resistant concrete should not overlook this important and highly significant fact.

In conclusion, let me repeat that the requirements for frost resistant concrete are only those already accepted as necessary for quality concrete. However, experience has indicated that more than average care should be taken to have it impermeable and of low porosity and absorption, especially in those places where the structure may be wet for considerable periods of time. Harsh mixes, coarse sands, excess water and segregation from whatever cause, should be avoided. Finally, concreting should be done only under competent and adequate supervision. These are in brief, the requirements for frost resistant concrete.



The Fluorescent Lamp

Its Auxiliary Equipment and Operating Characteristics

By G. F. Mudgett, Manager Illumination Dept., Canadian Westinghouse Co. Ltd., Hamilton, Ontario

(Continued from August.)

1. Voltage

As with incandescent lamps, variations in supply voltage produce variations in light output. Within reasonable ranges, it may be assumed that a one percent voltage drop decreases the light output 2 percent while a one percent rise increases it by 2 percent. This is shown on the characteristic curves, Fig. 5. Auxiliaries are designed for three standard voltages—118, 208, 236. In general, best lamp performance is obtained when line voltage is kept within the rating limits of the auxiliaries. At either under or overvoltage conditions, the lamp electrodes do not operate at their greatest effectiveness. At lower voltage electrodes do not reach high temperatures and they are overworked, while overvoltage causes excesive heating that quickens the loss of the emissive material. The result in either case is shortened life accompanied or preceded by excessive blackening. Also, high voltage may over-heat the auxiliary while under-voltage may cause uncertain starting.

Occasionally, even though available line voltage is satisfactory, low voltages occur due to momentary overloading of the line, or other emergencies. For most fluorescent lamps, a drop of more than 25 percent will extinguish the lamp; its period of restarting upon return of voltage will depend on the type of switch in the control circuit. Fluor-

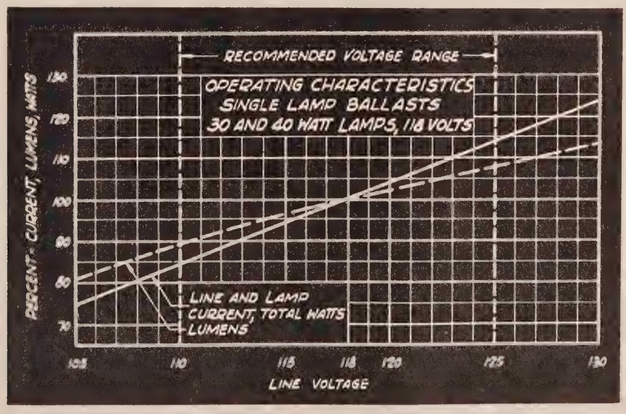


Fig. 5—Effect of voltage on fluorescent lamp characteristics.

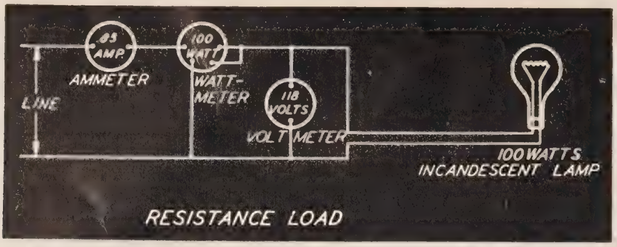


Fig. 6—Incandescent lamp load. Power factor is 100 per cent.

escent lamps are, therefore, not satisfactory for "dimmer" service.

2. Frequency

The current limiting characteristics of the reactor or high reactance transformer depend directly upon the power supply frequency for which units are designed. With lower frequencies, the reactance is reduced, and higher current will flow through lamp. Shorter lamp life and overheated auxiliaries will result. With higher frequencies, less current will flow with similar adverse effects on the lamp life and its lumen output.

Auxiliaries must, therefore, be designed specifically for particular frequencies. Operation at frequencies less than 60 cycles, seriously increases the problem of stroboscopic effect and, therefore, standard equipment is not available.

3. Power Factor

On alternating current circuits, the statement that volts multiplied by amperes equal watts, holds true only when the voltage and current are "in phase". The amount of phase difference is called "power factor" which equals watts divided by volts times amperes. If watts equal volts times amperes, power factor is 1.0 or 100 percent. However, 100 percent power factor only occurs when the energy consuming device is a pure resistance type (for example, an incandescent lamp) or if a number of different devices neutralize each other. For example, Fig. 6 gives the electrical values in a circuit with an incandescent lamp load. Note that current is .85 amperes and power factor is 100 percent.

However, the reactor or high reactance transformer used with fluorescent lamps produces a definite "out of phase" relation between voltage and current which results in a power factor of about 55 percent. Fig. 7 shows a 100-watt fluorescent lamp load. Note that current has increased to 1.54* amperes and a power factor of 55 percent. At a power factor of 55 percent current is increased 82 percent over that for a similar load with 100 percent power factor.

Since low power factor in fluorescent lamps is primarily a result of the reactance, it may be raised by the addition of a capacitor or condenser to the circuit. (Fig. 8). Note that the current is reduced to .94 amperes and the power factor corrected to 90 percent. The exact rat-

*Note: The value of 1.45 amp. (Fig. 7), should read 1.54 amp.

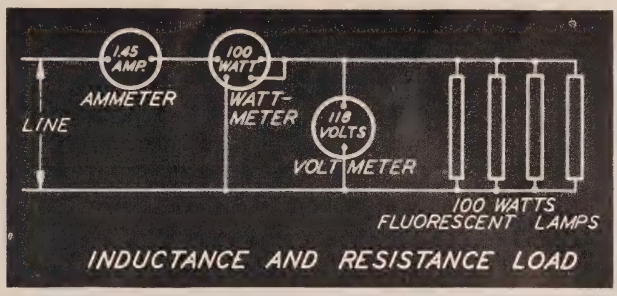


Fig. 7—Fluorescent lamp load. Power factor is 55 per cent.

ing of the capacitor depends on the degree of correction desired and the size and number of lamps to be balanced. While a capacitor may be placed anywhere in a circuit to improve power factor, its effectiveness in reducing current is only from the point of application to the source of power. Therefore, it should be placed near the lamp. With capacitors available which are designed to fit in wireways or in the lighting unit itself, no particular difficulty should be encountered in doing this. Occasionally, other considerations suggest the use of one large capacitor for a complete installation but, in this case, all branch circuits and branch circuit equipment must be designed for the larger current accompanying the lower power factor.

Single lamp ballasts with power factor correction and two-lamp auxiliaries are particularly effective since power factor correction is an integral part of each unit.

4. D.C. Operation

The fluorescent lamp is basically an a.c. lamp and while adaptable to d.c. cannot be expected to give equal performance. All published ratings are based on a.c. operation.

By adding suitable resistances to thermal switch control circuits (Fig. 9) and to certain other types of circuits, 15- and 20-watt lamps may be operated with reasonable satisfaction, although their life, over-all efficiency and lumen maintenance are adversely affected. With 30- and 40-watt lamps, specific trouble with starting and non-uniform output may

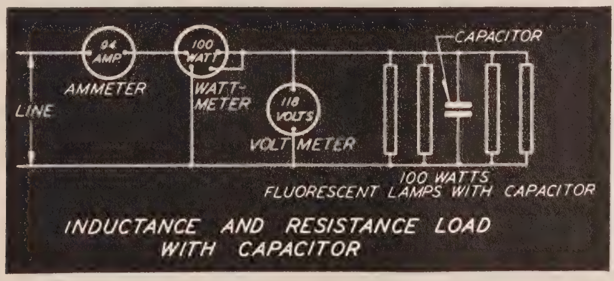


Fig. 8—Fluorescent lamp load with power factor corrected to 90 per cent.

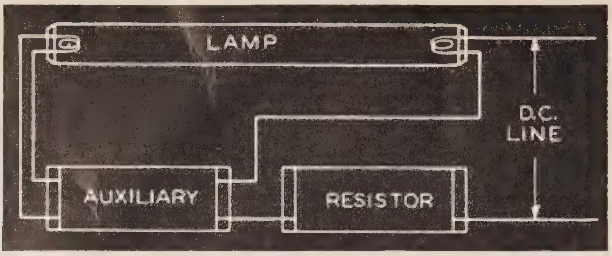


Fig. 9—Method of connecting resistors in circuit.

be experienced, and their use on d.c. is not recommended. This trouble is due to the bombardment of electrons in one direction only, which among other things, pushes the heavy mercury molecules to one end of the tube. Sufficient argon may remain around the anode to start the lamp and maintain operation, but the first foot or so of the bulb will remain a dull red indicating the absence of short wave ultraviolet. Occasionally the available voltage, the bulb temperature, and the angle at which the lamp is burned may combine to eliminate this condition but no assurance can be given.

The glow switch is not suitable for d.c. operation even with a resistance. Usually no harm occurs if this is tried, but the lamp generally will not start. Occasionally the lamp may operate but this is unusual and depends on minor variations of the switch which occur within manufacturing tolerances.

5. Stroboscopic Effect

It is characteristic of all a.c. light sources that there is some variation in light output dependent on the cyclic variations of the current. With incandescent lamps, this is negligible since the filament retains enough heat to compensate for the variation of the current throughout each cycle. With fluorescent lamps, the carry-over of light is dependent wholly on the phosphorescent qualities of the coating. This characteristic of the phosphors varies considerably. The phosphor used in the green lamp has the brightest carry-over, while the phosphor for the blue has the least.

The relative stroboscopic effect of certain lamps and combinations of lamps is given in Table II. The standard Westinghouse two-lamp ballasts reduce the stroboscope's effect to a point where in ordinary applications it is negligible. Where still further reduction is necessary three-phase operation of three adjacent lamps may be used. The minimizing of stroboscopic effect is an important consideration where moving objects are viewed or where the eye itself is moving rapidly. Stroboscopic effect is not to be confused with "whirl" or extreme flicker which occasionally occurs in a lamp which has not been seasoned properly in manufacture; where some emission material is temporarily in the arc stream; where there is some defect of installation, or where the lamp is near the end of life.

TABLE II

COMPARATIVE STROBOSCOPIC EFFECT OF VARIOUS LAMPS

	Lamp and Method of Operation	Relative Stroboscopic Effect*
1.	200-Watt Incandescent	1
2.	40-Watt Incandescent Lamp	7
3.	Green Mazda F—Single Lamp	11
4.	White Mazda F—Single Lamp	19
5.	Daylight Mazda F—Single Lamp	21
6.	Blue Mazda F—Single Lamp	23
7.	White—2 Lamp Ballast	9
8.	Daylight—2 Lamp Ballast	10
9.	Daylight or White—3 lamps, each on a different phase of a 3-phase circuit	3
10.	White—3 lamps, one on individual ballast, remaining pair on two lamp ballast	14
11.	Daylight—3 lamps, one on individual ballast, remaining pair on two lamp ballast	15

*Based on ratio of light output during cycle above mean average to total output at mean average.

6. *Brightness*

The larger surface area due to extended length and the high diffusion of the Mazda F lamp result in low brightness even though the total light output is high. When lamps are exposed, the use of the larger diameter lamp is always suggested unless the lamp is placed in an extremely favorable position. Since angle of viewing, background and other factors must be considered, no definite recommendation on brightness can be given. The figures in Table III, however, may be compared with a standard enclosing globe which in the normal field of view is considered acceptable if its brightness is about 3 candles per square inch.

7. *Coolness*

The heat from any light source is in direct ratio to its energy consumption. In terms of heat, one watt-hour is equivalent to 3.4 B.t.u. From

TABLE III

BRIGHTNESS OF FLUORESCENT LAMPS

Candles Per Square Inch

Lamp Size	White	Daylight	Blue	Green	Gold	Pink	Red
18 in. x 1 in.	4.5	3.9	2.5	7.0	3.6	2.3	.4
18 in. x 1½ in.	3.0	2.6	1.7	4.7	2.4	1.5	.3
24 in. x 1½ in.	3.6	3.1	1.9	5.3	2.2	1.8	.3
36 in. x 1 in.	5.5	4.7	3.0	8.7	3.5	2.9	.5
48 in. x 1½ in.	3.9	3.3	----	----	----	----	--

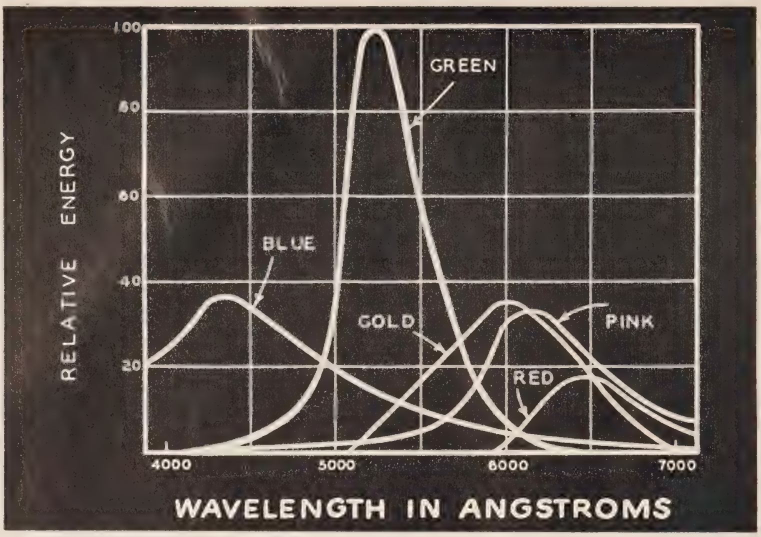


Fig. 10—Spectral distribution of various colored fluorescent lamps.

this, it is apparent that considerably higher levels of lighting are possible with the more efficient Mazda F lamp with an equal degree of comfort. Naturally, the heat losses of auxiliary equipment must be included with the lamp wattage if within the same room or enclosure.

Total heat, however, is not always the important consideration. Quite frequently the form of the heat is of more importance. With a fluorescent lamp, only half of the heat is radiated, the rest being lost by conduction and convection, usually upward. The ratio of heat received by a person or object in close proximity to a fixture may be only one-sixth or less with a fluorescent lamp than with an incandescent lamp, producing the same foot-candles.

8. Color

The word "color" is a very general term and it is important to appreciate its scope when considering fluorescent lamps. For example, the radiated energy of the green lamp is confined to a narrow band and it may truly be called a source of green light (See Fig. 10). On the other hand, the blue lamp covers a much broader range. While blue in appearance, it might be more critically termed a "pastel blue", implying that there are enough other radiations to add a synthetic white to the blue. This is obviously true for the pink lamp; pink is actually "pastel red". This distinction of color is seldom important except where special effects are desired; as when colored lamps are being considered for general lighting of interiors.

The white lamp is not an exact match for the incandescent source, nor is the daylight lamp an exact reproduction of natural daylight. Yet, under most conditions, the eye can detect little difference from a seeing standpoint. Neither lamp is suitable for

critical color matching or exacting color discrimination.

The primary differences between fluorescent lamps and natural light are (1) the lack of a deep red and (2) the presence of the spectral lines of a normal mercury discharge. The former, unobtainable at present from phosphors of satisfactory efficiency, is sometimes of importance where deep reds, such as in raw meats, must be viewed. The second difference, noticeable by a slight yellow-green distortion of certain colors, becomes important where certain colors are used for interior decoration. Unless previously used, a proposed color scheme should be examined with the light under which it is to be used. In all cases where color appearance is important, the use of fluorescent lamps should be carefully analyzed.

9. Lamp Life

The rated average laboratory life of the fluorescent lamp is 2,500 hours. This is the life obtained when lamps are tested on approved auxiliary equipment at its rated line voltage and frequency.

Since very frequent starting will affect the life adversely, fluorescent lamps are not recommended for services of a type similar to the flashing of lamps in signs.

10. Lumen Maintenance

The light output of a fluorescent lamp decreases somewhat during its life. The depreciation at 70 percent rated life of the average Mazda F lamp is about 15 percent. It should be noted, however, that during the first 100 hours of life, the drop in light output is more rapid than during subsequent burning hours. It is for this reason that the published "initial" lamp-lumen and lumen-per-watt values apply at the 100-hour point. This conservative basis of lamp rating explains the somewhat higher levels of light output often experienced with a new installation. The snow white appearance of the standard phosphors is gradually blemished by blackening which is relatively insignificant from an output standpoint. This is emphasized by the non-uniformity of the blackening, which tends to collect opposite or near the cathodes. Noticeable blackening prior to 750 hours is generally caused by improper operating conditions (voltage, bulb temperature, choke characteristics, starter defects, etc.). Trouble from such conditions can be found by investigation and must be corrected for best service.

11. Temperature

Lumen output values of the Mazda F lamp are obtained when measured at 80 deg. fahr. ambient temperature. This would indicate a bulb wall temperature slightly higher (100 to 120 deg. fahr.), within which range lumen output is approximately unchanged. The light output will decrease about 1 per cent for each one degree drop in bulb temperature below 100 deg. fahr. While this is not absolutely accurate, it is close enough for field estimates. While the arc will usually strike at temperatures as low as zero degrees Farenheit, early blackening and short life may result from low temperature operation.

It must be emphasized that the above statements concern the temperature of the bulb. While all fluorescent lamps are of low wattage and relatively cool, there is obviously some

generation of heat. Thus, the bulb may be considerably warmer than its surroundings unless cooled by moving air. The protection afforded by a reflector is often sufficient to trap enough heat to assure satisfactory lamp operation even at freezing temperatures. Better results will be achieved by the use of a cover glass for the reflector or some other means of directly protecting the bulb. Auxiliary heating may be employed (resistance coils or incandescent lamps in the same enclosure) but this should be necessary only when it is imperative to have maximum light output at all times or when extremely low temperatures are continuous.

Above 120 deg. fahr. the light output also drops but not nearly as quickly as with low temperatures. Up to 200 deg. fahr., an approximation for field use would be a one per cent light decrease for a three degree bulb temperature increase. Temperatures above 200 deg. fahr. are rarely encountered where fluorescent lamps are considered applicable.

The change in light output is due largely to the change in character of the arc discharge which alters the relative amount of ultraviolet generated and thereby affects the subsequent production of light by fluorescence.

Because of the changes in arc characteristics at low temperatures, fluorescent lamps may not operate satisfactorily on circuits controlled by glow relays. At temperatures below freezing, the high voltage existing across the lamp may cause the switch to alternately open and close which prevents the arc from being established.

12. Radio Interference

The fluorescent lamp, since it is an arc discharge, may cause radio interference. The exact nature of this interference is being actively studied and it is reasonable to assume that some of the effects will be eliminated gradually. Well grounded fixtures, short leads from lamp to reactance, metal mounting for sockets, all aid in producing a trouble-free installation.

Interference does not seem to be cumulative. That is, ten lamps would cause only slightly more than one lamp. By outside antennas or other means, increased ratio of signal to interference can lessen the effect of any disturbance. Under certain conditions, a condenser from each side of the line to ground at the receiver may be needed although most of the better grade radio sets are protected in this way.

13. Noise

With any reactor or high reactance transformer, there are certain to be some audible frequencies generated by the alternating magnetic force pulling on the iron laminations. Fluorescent auxiliaries are now designed to minimize this inherent "hum". Frequently a hum is changed to noise by amplification due to the mounting of the auxiliary on some resonating surface. Good installation practice calls for (1) stiffening of long troughs; (2) sound deadening such surfaces where stiffening is difficult; and (3) fastening auxiliaries by screws with sound insulating sleeves, washers, and pads to prevent the transmission of hum.

It is probable that hum will never be completely eliminated from some

types of auxiliaries because of commercial and economic limitations. However, certain well-made auxiliaries, particularly of the two-lamp type, are now available in which hum is only audible when the unit is close to the ear. Hum is usually not objectionable in factory spaces or other areas where noise always prevails to a certain degree. However, in quiet rooms, or when the light source operates close to the user, the hum may become annoying and it may be necessary to locate auxiliaries at a remote point or in sound-proof cases. Hum or noise is additive, so that a single unit which may not be objectionable might be combined with sufficient other units to require special attention.

14. Vibration

While no doubt extreme vibration will have a damaging effect on the life of Mazda F lamps, they appear to be able to withstand more than the ordinary conditions encountered in lighting service. The arc itself is unaffected, and since the electrodes burn at relatively low temperatures and are mounted in a vibration-resistant manner, it may be assumed that they can be applied satisfactorily in locations where vibration is present. Naturally, the lamps must be installed in the sockets in such a way that they do not shake out or create external arcs due to poor contacts.

Instruments in Science and Industry

By Robert S. Whipple

THE help that instruments have given to the advancement of science is a fascinating theme, and at the same time a wide one. Among the earliest and most striking examples we find that Kepler was able to state his Laws of Planetary Motion as a result of the observations made with Tycho Brahe's carefully-constructed instruments. Tycho (1546-1601) first introduced, though he did not discover, the method of transversal division of the arc, which is now familiar to us as the basis of the diagonal scale. It was he who first pointed out the importance of symmetry in an instrument. The ingenious naked-eye sights developed by him were a remarkable improvement on the simple sights previously used.

I propose to consider a few well-known instruments and to use them as examples to indicate how the development of a particular subject has grown largely with the perfection of the instruments used to investigate it. It is in every way a reciprocal process. By means of an instrument certain evidence is obtained; this evidence does not go far enough and the instrument must be improved to enable further facts to be found. As examples of instruments primarily used to extend the range of our senses I will take the microscope, telescope and spectroscope. Their development has a long history, and each can be adapted to yield accurate measurements by the addition of suitable devices. Thus we are led to the application of the mechanical arts to the division of angles and lengths in dividing engines and the measurement of time by various appliances which may be considered as supplementary to those first mentioned. To exemplify classes of instruments, the use of which rapidly extended from the laboratory to the industrial field, I will review those employed in temperature measurement, including the galvanometer, and, as an example of the rapid application of new physical knowledge by the instrument maker, the thermionic valve as applied to measurement.

The first example I shall take is the microscope, an instrument which is used in every observational science and, in some form or another, in nearly every industry. The first instruments consisted of single lenses, actually small globules of glass, which, when the surfaces were suitably ground, yielded in the hands of skilled observers surprisingly good results. The outstanding example is the Dutch naturalist Leeuwenhoek, who during the period 1674-1723, using a microscope of this type,

From the Presidential address, delivered to Section A of the British Association, at Dundee, on August 31, 1939.

discovered the protozoa and bacteria, and made many other biological observations of supreme importance. Hooke, who was Leeuwenhoek's correspondent, was working at microscopical problems at the same time, and in the *Micrographia* (1665) described his own microscope—the first compound microscope. The optical system of this instrument consisted of a converging lens, called the object-glass, the field lens, and a third lens, the eye lens. Although it has been stated frequently that Hooke first introduced the field lens to enlarge the field of view, there is little doubt that this invention was due to Monconys, who published a short description of a compound microscope made to his design in 1660. This hardly detracts from the credit due to Hooke, whose publication became so generally known, and whose optical system was universally adopted and remained practically unchanged for over a hundred years. Hevelius, in 1673, described in his *Machina Coelestis* a screw-focusing adjustment that he had fitted to an instrument of the Hooke type which was the forerunner of the modern mechanism adopted (or invented independently) by John Marshall (1663-1725), one of the great opticians at the close of the seventeenth century. Marshall should be remembered by the fact that he was the first to introduce the method of grinding a number of lenses simultaneously, by cementing a number of pieces of glass on to the surface of a large convex spherical block, and working them with a concave spherical tool. This is still the method employed for polishing lenses in quantity. In the modern spectacle-lens factory as many as 150 are sometimes polished in one block.

Although many variations in the design and mechanical construction of the microscope were made during the Eighteenth Century and the early years of the Nineteenth, yet there is no invention of fundamental importance to record until the construction of the achromatic objective. This was first successfully completed by the French optician, Chevalier, about 1825, and in England by Tulley, working about the same time, to the designs of Joseph J. Lister, nearly sixty years after the construction of a successful achromatic telescope objective. Abbe carried the corrections of the aberrations to a far higher degree of perfection, notably by using glasses of new types, which at his suggestion had been worked out by Schott, to produce about 1886, the so-called apochromatic objective in which the colour correction was greatly improved. It is difficult to see how the resolving power of the microscope is to be further increased using light from the visible region of the spectrum. The biologist, and particularly the medical man, is anxious to study organisms the structure of which is too fine to be resolved by any object glass when using ordinary white light, the alternative to which is the employment of rays of shorter wavelength, viz., the ultra-violet. Glass lenses are opaque to these short wavelengths, and therefore lenses made of fused quartz must be used.

The use of short-wave radiations has proved so successful in the case of the ultra-violet microscope that a tech-

nique has been developed which offers great possibilities for the use of still shorter radiations. As is well known, a beam of cathode rays can be brought to a focus by passing the beam through a magnetic or electrostatic field, in a manner very similar to that in which light is brought to a focus by a convex lens. In the same way, an electron image of a surface may be formed owing to the fact that the electrons will be scattered by an amount depending on the density, or mass concentration, of the surface on which they impinge. By forming the image on a fluorescent screen it can be rendered visible, or if projected on to a sensitised plate, photographically recorded.

Although the discovery of the telescope ante-dated that of the microscrope, in its service to mankind it ranks as second to it. The credit of the invention of the telescope must go to a Dutchman, Lippershey; yet it was Galileo who first produced an instrument worthy of the name. He ground and polished his own lenses, and, in 1610, with a telescope magnifying 33 diameters, discovered the satellites of Jupiter. Among his many astronomical observations he discovered the phases of Venus, and estimated the height of the lunar mountains from the length of their shadows. Newton pointed out that the focal length of the refracting telescope could not be reduced owing to the refrangibility of light of different colours, and that it was not possible to focus for all the colours simultaneously and thus obtain a sharp image. He measured and calculated the distance between the foci of the red and violet and showed that it was about one-fiftieth the diameter of the lens. It was to overcome this difficulty that the glasses were made small and of long focal length. It is almost unbelievable that James Bradley, in 1722, measured the diameter of Venus with a telescope having a focal length of 212 ft., the supporting mast being about 45 ft. long.

In 1663, James Gregory suggested the construction of a reflecting telescope, and in 1668 Newton constructed the first practical instrument, having made his own alloy for the mirror and having devised methods for grinding and polishing it. The manufacture of satisfactory reflectors was very difficult, and it was not until an instrument maker, James Short, of Edinburgh, about 1730, produced instruments with parabolic figuring, that the reflector came into general use. His instruments, even now, may be regarded as examples of first-class workmanship. Sir William Herschel began making specula in 1774 and constructed a large number of reflecting telescopes, the most famous being his instrument at Slough of 4-ft. aperture and 40-ft. focal length; this was completed in 1789. Unfortunately, the weight (25 cwt.) of the large speculum rendered it liable to distortion and it is of interest to note that all Herschel's discoveries were made with smaller instruments. More than fifty years later a reflector of 6-ft. aperture and 54-ft. focal length was erected by Lord Rosse at Parsonstown. All these instruments were fitted with metal mirrors which had an unfortunate tendency to tarnish, and repolishing was apt to spoil the figuring

of the mirror. In the modern instrument the metal mirror is replaced by glass which can be re-silvered at intervals. During the last few years aluminium has taken the place of silver as the reflecting surface, the aluminium being deposited on the glass surface under vacuum. The aluminum film does not tarnish, is more robust than silver, and has a higher coefficient of reflection for short wavelengths, and is thus more efficient photographically.

Owing to the increasing demand for telescopes of higher magnification, and of increased light-gathering power, the size of the mirrors used in the modern instruments is steadily increasing. The Mount Wilson Observatory has a telescope with a mirror 100 in. in diameter, and it is a matter of common knowledge that magnificent photographs of nebulae, etc., have been obtained with it. At the present time an instrument having a mirror 200 in. in diameter is being constructed for the Mount Palomar Observatory. The manufacture of the borosilicate glass (Pyrex) block for this mirror, which weighs 20 tons, has been a feat of considerable skill, and if it is successfully ground and polished, as appears likely, it will be a great engineering triumph. It is difficult to realize the accuracy of grinding and polishing required in these large mirrors.

In 1733, Chester Moor Hall found that by combining lenses made from glasses having different refractive indices, he was able to correct for the unequal refrangibility of light of different wavelengths, and succeeded in making lenses which produced images free from colour. The same discovery was made independently by John Dolland, who, in 1758, produced an achromatic telescope in which the object glass consisted of a convex lens of crown glass combined with a concave lens of flint glass. The invention of the achromatic lens must be considered as one of the milestones in the development of scientific instruments—its importance in nearly every piece of apparatus employing a lens can hardly be exaggerated.

(To be Continued.)

System Loads in August

WHEN comparing the system loads of The Hydro-Electric Power Commission of Ontario in August, 1940, with those of August, 1939, there is an increase in the total of the primary loads taken by all of the systems of 14 per cent. During July the corresponding increase was 14.7 per cent and resulted from a comparatively uniform increase in loads in all of the systems excepting Georgian Bay, where the 1940 load was but slightly greater than that of 1939. In August of this year the increases in the different systems over 1939 are all slightly less than in July excepting Georgian Bay and Eastern Ontario. The Niagara system increase of 15.9 per cent in July dropped to 15 per cent in August, the Thunder Bay system increase of 12.9 per cent dropped to 9.7 per cent, and that for the Northern Ontario Properties from 15.5 per cent to 15.3 per cent. Eastern Ontario system, however, increased its load in August by 11.2 per cent, the increase for July being 10.5 per cent, and in the Georgian Bay system the August increase was 2.4 per cent compared with zero in July.

The tabulation of the system loads for the month of August is as follows:

System	Maximum 20-Minute Peak H.P.		Per cent Increase
	August 1940	August 1939	
Primary Loads			
Niagara	1,126,408	979,893	+15.0
Eastern Ontario	141,732	127,401	+11.2
Georgian Bay	39,697	38,757	+ 2.4
Thunder Bay	94,169	85,858	+ 9.7
Northern Ontario Properties	193,962	168,283	+15.3
Total of All Systems	1,595,968	1,400,192	+14.0
Primary and Secondary Loads			
Niagara	1,390,617	1,265,550	+ 9.9
Eastern Ontario	142,194	158,956	—10.5
Georgian Bay	40,099	38,757	+ 3.5
Thunder Bay	94,169	124,920	—24.6
Northern Ontario Properties	220,101	215,870	+ 2.0
Total of All Systems	1,887,180	1,804,053	+ 4.6

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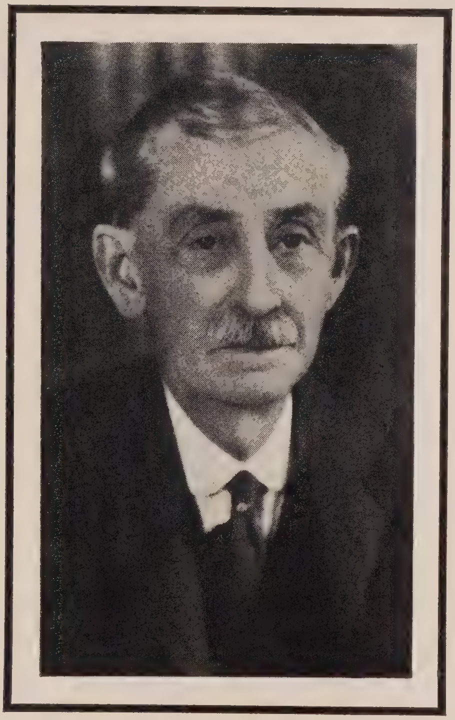

Major W. W. Pope

FOR over twenty-six years Secretary of The Hydro-Electric Power Commission of Ontario, Major William Walter Pope died at his home in Streetsville on Friday, October 4th, 1940, in the 91st year of his age.

Major Pope was born in Compton, County, Quebec, being of United Empire Loyalist descent, and it was

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October, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

there he received his early education. As a young man he worked with the old Boston, Clinton and Fitchburg Railway for about four years, and later engaged in the lumber business in Belleville, Ontario. In 1874 he took up the study of law at Belleville, and in 1876 became assistant to the late John Bell, K.C., solicitor of the Grand Trunk Railway. Here he remained until 1905, when he was transferred to Montreal as assistant to W. H. Biggar, K.C.

In October, 1909, Mr. Pope came to The Hydro-Electric Power Commission of Ontario, as solicitor and secretary. As solicitor of the Commission during its early days, he had much to do with legal work arising out of relations between the Commission and the Hydro municipalities, and also in the preparation of legislation needed because of the steady growth of the Hydro system. He remained secretary of the Commission until his retirement in February, 1936.

After his retirement he was retained as secretary of the Municipal Hydro-Electric Pension and Insurance Plan until the summer of 1938.

He was a Fenian Raid veteran, having served with the Cookshire Cavalry of Quebec. He held the rank of Major in the 15th Regiment, Belleville, Ontario, and from which he retired in 1909 with a long service decoration. While in Belleville he was interested in municipal affairs and served for a time as alderman.

As a member of the Hydro staff, Mr. Pope was held in the highest esteem by all. He took an active interest in matters pertaining to the staff and assisted in the working out of many of the benefits now enjoyed. Whenever possible he attended staff functions, and at times assisted with the programme, even after his retirement. At the dinner of the Quarter Century Club of the Commission a year ago he was present as guest speaker. His last public appearance was at the Beck Memorial Ceremony at Hamilton cemetery last August.

Engineers In The War

By Dr. Thomas H. Hogg, Chairman and Chief Engineer, The Hydro-Electric Power Commission of Ontario and President, The Engineering Institute of Canada

CAPTAIN DAVIES SAVES ST. PAUL'S

CAPTAIN ROBERT DAVIES' gallant action in extricating the large high explosive time bomb which momentarily threatened disaster to St. Paul's Cathedral, in the heart of the Empire, was a feat which stirred the hearts and imagination of every loyal British subject.

Captain Davies and his suicide squad knowingly risked their lives to save an historic monument which well symbolizes the democratic freedom for which we are fighting.

It was a job well done. But it was not attempted in any haphazard way. It needed a courage which few of us possess, but more than that it needed knowledge. Unexploded, high-explosive bombs are exceedingly temperamental and only experienced and understanding explosive experts are allowed to handle them.

It was an engineering job, and Davies, who is a Captain in the Royal Engineers and has been specializing in this work for some time, undertook the delicate task of rendering harmless this large time bomb. His success was a notable achievement and we in Canada are proud to know that Captain Davies has been awarded the George Cross—the first to receive this signal honour at the hands of His Majesty, The King.

GENERAL MCNAUGHTON—DISTINGUISHED ENGINEER

In Canada, following the outbreak of war, the government recalled Major General A. G. L. McNaughton, now Lieutenant-General, from his peace-time work as President of the National Research Council to command the First Division, Canadian Active Service Force.

General McNaughton is an officer of outstanding military qualifications, but he is also a distinguished engineer. He was responsible for the development of an aeronautics laboratory at Ottawa long before war broke out, and this laboratory has been of great service in our war-time effort.

Where can we find greater self-sacrifice, greater devotion to public welfare, than in the several branches of our Canadian Active Service Forces? In all of these the engineer plays an important part and General McNaughton himself is perhaps the perfect embodiment of this professional engineer's spirit. Under him are hundreds of others trying to emulate his example, using their native talents, their engineering education, and their engineering experience to further and protect our civil-

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Radio Address broadcast by the Canadian Broadcasting Corporation and sponsored by the Engineering Institute of Canada, October 16, 1940.

ization in a world menaced by hordes who would destroy everything we hold dear.

Military and Civil Engineers

In considering the relationship of the engineer to the war, it is interesting to recall that prior to the 18th century the mechanical and constructional arts were almost entirely the vocation of the military engineer. It was only in the latter part of the 18th century, little more than 150 years ago, that there arose a body of men who confined to beneficial purposes their skill in these arts, and became known as civil engineers in contrast to military engineers.

Today, in a very much widened sphere embracing the main branches of civil, mechanical, electrical, mining and chemical engineering, and their many subdivisions, the majority of engineers are concerned with civil projects of a constructive character. The difference in the aims of the two broad groups of engineers, civil and military, is well expressed in the definition of his profession early adopted by the civil engineer, which was—"The art of directing the great sources of power in nature for the use and convenience of man."

In peace-time the military engineer is concerned with many projects of a constructive character relating to defence measures, but in war-time even his constructive efforts relating to bridge and highway building, the maintenance of transport and communications, etc., are all related to a destructive end—namely the destruction of the power of the enemy. Nevertheless much of his training is fundamentally similar to that of the professionally civil engineer.

It is not surprising, therefore, that under conditions of modern warfare, mechanized to the limit and exploiting all the scientific and engineering achievements of the past fruitful decades of progress and research, the civil engineer, with his specialized training, is called upon to take a prominent part in the change in the country's economy from a peace-time to a war-time basis.

We find, therefore, that many leaders in our war-time activities are men who have been prominent as civil engineers in peace-times.

On the Home Front

On the home front an engineer very prominent in the public eye at the present time is the Honourable C. D. Howe, Minister of Munitions and Supply, who is directing Canada's industrial army. He was formerly a well known civil engineer, and today has the important task of organizing industry to produce the maximum quantity of munitions and supplies in the minimum time.

Associated with Mr. Howe, both directly and indirectly, are a great many Canadian engineers, specialists in various branches of engineering, all applying their specialized knowledge, which may be technical or administrative, for the quick solution of urgent problems. These engineers, co-operating with engineers engaged in industry, are endeavouring to mobilize efficiently and in the shortest possible time the great resources of this Dominion and direct a continuous stream of munitions and supplies through unimpeded channels to their ultimate destination.

An Engineering Problem—Transportation

We know that war today is a complex economic struggle, but some of the old military dictums still hold good; and one is: to win battles it is necessary to have men and materials in the right place at the right time. This entails a complex engineering problem—transportation. Men must be carried in mechanized units by land, air and sea; artillery must be strategically located; munitions of all types must be continuously distributed; and food, gasoline and supplies of a varied nature must be transported.

The problem and strategy involved in depositing high explosives upon military objectives in the enemy's territory is also a major transportation problem, whether this is accomplished by aerial bombers, ships' guns, land guns, or by infantry. And being a transportation problem it requires the best engineering skill available to ensure its success.

Perhaps nothing so typifies the spirit of the British people as the Navy. The fighting ships of today are themselves concentrated marvels of engineering skill, requiring for their operation and maintenance engineering ability of a high order. So too with the Air Force. The undoubted superiority of the planes of the Royal Air Force is attributable both to the professional ability of the designing engineer and the long tradition of fine craftsmanship in the engineering factories of Britain.

As you know, airplane production in Canada is fast developing into an important contribution to our war effort, but it may be news to many of you that a woman graduate of Toronto University is a prominent engineer in this newest transportation industry. Later in this series there will be a talk on "Aircraft Engineering" by Miss Elizabeth M. MacGill who is chief aeronautical engineer to the Canada Car and Foundry Company of Fort William.

Machines or Men

Unquestionably success in this war will largely depend upon the wholehearted co-operation of industry, especially the engineering industry. Machines are playing a vastly more important part than ever before. It is mechanized forces that fight this war. The tank and the aeroplane, modern transport of all sorts, new and more costly weapons, these are the realities of today.

Everywhere there are new and expanding needs for mechanization. I think I am right in saying that a battalion of 1,000 men, in the last war, was equipped with only two machine guns. In this war a battalion of 700 men will carry fifty. It is the hope of every one of us, I am sure, that machines may this time take some of the punishment which in the last war was borne by flesh and blood.

Canada and Canadian engineers have a very definite part in all this. Canada is not represented only by an Expeditionary force. Behind the army in the field there must be mobilized a vastly greater army of technicians and workers; and Canada's greatest contribution will only be achieved after she has organized herself into a vast machine shop, a vast

storehouse on which our Empire may call, to meet any need that may arise. Surely it must not be again, as unfortunately it was in the last war, that men were called upon to die because industry at home was inadequate to serve their needs.

During the first World War our own Canadian divisions were largely armed, supplied and trained overseas. Today we are planning to equip them in every detail of their needs. We are also the training ground for the vast air effort of the Empire. Men from every quarter are converging here to learn that art of aerial war. Much more than was the case in the last war, we are being industrially mobilized in this war.

THE ENGINEERS' CONTRIBUTION

Fortunately due to our great industrial development since 1914, it is a far stronger Canada that stands today by the side of Britain—stronger in both men and materials, experience and stamina. Thousands of Canadian engineers, who have contributed so much to the peacetime economic development of this great Dominion, are now concentrating all their skill and experience upon war-time activities.

Great individual contributions are being made by engineers in almost every branch of engineering, but I would like to pay particular tribute to those engineers who voluntarily are giving their time and talents in a hundred different ways to strengthen Canada's war efforts. These engineering services range from those given by the unpaid specialists at Ottawa to those given by veteran engineer officers of the last war who are spending their nights to train young sappers and engineer officers of the Non-Permanent Army.

The Engineering Institute of Canada, which is a Dominion-wide organization, in co-operation with other professional engineering associations, is trying to find ways and means of doing voluntary work. As far back as 1938, the Canadian engineering organizations, at the request of The Department of National Defence, made a notable contribution by gathering together the academic and professional records of approximately 10,000 Canadian engineers and technically trained men. This voluntary census, completely indexed and filed, is now of considerable help in locating technical men of the type that are so often urgently required for war work.

The Engineering Institute of Canada, with headquarters in Montreal, is not only continuing its peace-time function of disseminating technical knowledge and of consolidating the engineering profession throughout the Dominion, but with its wide knowledge of the profession is able to find the right type of engineer when asked by the various government departments and those firms carrying out special war contracts.

Problems involving the entire technical staff of new industrial units have been brought to the Institute's headquarters, and Canadian engineers with highly specialized experience have been found to fill positions of unusual responsibility.

This talk, I fear, has been somewhat of a eulogy of the engineer—so, if there are Canadian engineers

listening to me, I would ask them to remember their grave responsibility in this hour of need.

We cannot all remove time bombs or command armies, but in this war the civilian, and especially the men and women with engineering or technical training and experience, can contribute to the common effort as never before. The engineers and technicians who form so substantial and important a part of the Canadian active service forces can be relied upon to do their part. Upon the civilian engineers, who largely direct and control the vast industrial effort that may well be Canada's chief contribution to the Empire's struggle, is laid a still greater burden—greater because its acceptance is an individual responsibility. Let none of us fail in this.

Distribution for Modern Needs

By V. A. McKillop, Chief Engineer, The Public Utilities Commission, London, Ont.

THE privilege of talking to a Toronto audience about the distribution of electricity is appreciated. Several institutions and many individuals in Toronto have played important parts in the building of the electrical industry. The University, The Hydro-Electric Power Commission, the Toronto Hydro-Electric System, the manufacturers, have together produced for Ontario a wonderful asset. The people in other parts of the province have learned to look to Toronto for leadership in all phases of the electrical development. It is hoped that some mutual benefit may come from a presentation of the problems of a smaller municipality.

There was a temptation to talk about distribution systems in general, but it soon became apparent that the only course was to "Preach what you practise". The ideas set forth, therefore, will represent the practice in London or, in some cases, a goal for the future.

The distribution of electricity is similar in some respects to other retail businesses. The commodity must be moved from the wholesale house to the consumer in the most direct line without undue waste. There must be reasonable assurance regarding quantity and quality, or in electrical terms—continuity of supply and good voltage. The consumer learns to expect little inconvenience although the cost of his service has become less and less throughout the years. Lavish expenditure on equipment to prevent interruptions under almost every conceivable condition or to provide a perfectly even voltage might raise the price of electricity beyond the amount that the consumer is willing to pay.

Presented to Toronto Section, A.I.E.E., October 25, 1940.

Cost must be weighed against results. This policy was also expressed by an engineering executive of the Consolidated Edison Company of New York in the *Electrical World* recently in an article "Can Twenty-Four Karat Service Always Be Justified".

The public utility has a responsibility unknown to the private merchant because the dissatisfied customer in the former case cannot buy elsewhere. The public have a right to expect that in return for the monopoly granted, no effort will be spared to protect them against poor service. In determining the kind of service to be rendered, the utility will find that most people realize that storms and age still take their toll and are willing to make reasonable allowances. In endeavoring to provide the best service possible within the limits of available equipment and permissible cost, an effort should be made to constantly improve. The dependence placed on the electric service by all classes of consumers should be a perpetual incentive to better service. The motors of the manufacturer and lights of the merchant and the cooking and refrigeration and heating appliances in the home are a responsibility not to be ignored.

The circuits entering the municipality at 13,200 or 26,400 volts are of major importance and trouble may have far reaching effects. These lines may represent a "bottle neck" because they are few in number and may be grouped on one or two pole lines. The transformer station from which the lines have come may be another "bottle neck". Such conditions are dangerous to good service and should be eliminated wherever it is economically possible. These lines are frequently subjected to damage from storms for various reasons. They are at the top of the pole where trees, wind, rain, sleet and lightning find their best opportunity for interference. The poles are in open country or on the outskirts of the municipality where there is little or no protection from buildings. Maintenance of these lines is difficult and trouble is frequently traced to this fact. Whatever may be the reasons, the results are widespread when such a circuit "goes out". The substitution of underground cable for these high voltage, overhead lines produced a marked improvement in operating records. The expense of underground construction is the main obstacle to such a change. Results will usually be found to be entirely satisfactory and reduction in maintenance expense will go far to balance the additional cost. When a municipality has decided to adopt underground construction for these higher voltage lines, there are then several alternative methods from which to choose.

The original choice in London was 3 conductor, No. 0000, p.i.l.c. armoured cable for 13,200 volts from the Hydro-Electric Power Commission transformer station to Cabell Street. The error of this form of construction on a direct route from the source to a main point of distribution was recognized later, and additional cables were installed in ducts. Four ducts were laid on the north side of Hamilton Rd. with manholes up to 500 foot spacing. A similar group of ducts was installed some years later on the

south side of the same street, with manhole spacings reduced to about 350 feet. Some time later the temperature of the cables then in service was questioned, and a survey was undertaken. This survey was made the subject of a lengthy and valuable report by N. L. Morgan of the Northern Electric Company, Limited. The object of the survey, as stated in that report was to obtain data from which could be determined

1. The conductor temperature at one point throughout the day.

2. Distribution of conductor temperature and location of the hottest section of the line.

3. Maximum permissible load current.

4. Thermal resistivity of the soil.

The recommendations included a lower load rating, ventilation or some other correction for one hot spot, and a preference for grass rather than asphalt covering on future ducts.

The original armoured cable and the next three in the first duct bank went to one point, Cabell Street, and all were No. 0000. The first two cables in the second duct bank went beyond Cabell St. to other stations further west. Three hundred thousand cir. mils was the choice for these, after some consideration, and they were sufficient for four years. Then relief was provided by another No. 0000 cable in earth on a direct line from the H.E.P.C. to the east end industrial area. One year ago a 500,000 cir. mils cable was pulled into the Hamilton Rd. ducts from the H.E.P.C. to Cabell St.

The size of the last cable was the subject of a report by O. W. Titus of Canada Wire and Cable Co., in which much valuable information was provided. Past experience with growing loads and the few remaining spare ducts made the choice of size of particular importance. Three sizes of cable were compared on the basis of capital cost of cables and ducts, plus copper losses for some years in advance. Existing interest and power rates were assumed, as well as a continuation of load trends. The result was definitely in favour of a size larger than 300,000 cir. mils and 750,000 cir. mils showed a slight advantage over 500,000 cir. mils. In view of the assumptions which had been made and because of possible difficulty in installing the larger cable in existing duct sizes the 500,000 was selected.

At other times, on various parts of the system, there has been required a 13 kv. cable likely to be more or less isolated for many years. The streets involved were residential on a direct line between two substations, and under these circumstances no ducts were employed. Lead suffers no damage from the soil in London, and because the ability of the armour to protect the cable from a pick was doubted, plain lead cable has been used. Old bricks have been laid as a protecting cover on new cables. The additional capacity of one cable in earth as compared to the same cable in a duct bank, and the saving on installation costs is worthy of careful consideration where conditions permit. Cable in ducts lends itself more readily to repairs, location of faults and protection from damage than any underground alternative, and ducts

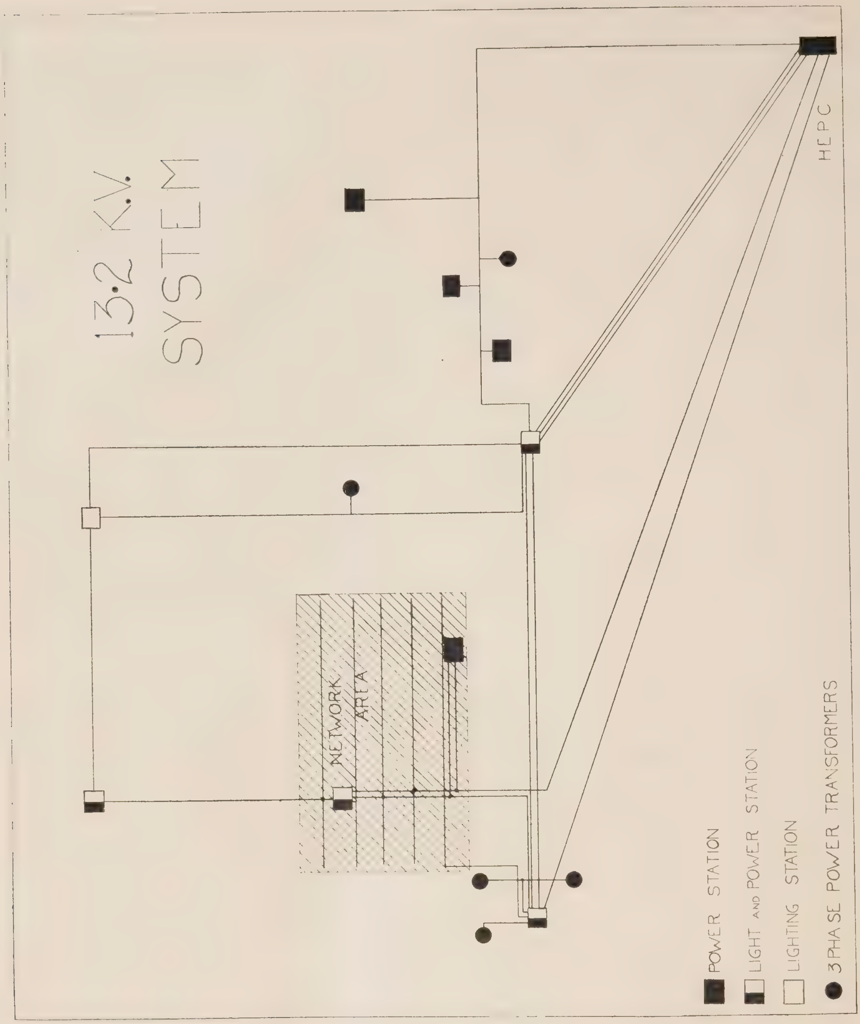


Diagram of 13.2 kv. system in London.

should not be omitted without a full understanding of this fact and a willingness to accept the consequences.

Sectionalizing of these cables may be very useful in emergencies. Oil switches for installation in manholes are available for this purpose. The need for such equipment is particularly obvious where a tap is made to serve a more or less isolated load. This switch is also useful on a loop system because it permits restoration of service to some consumers while repairs are being made elsewhere. These high voltage circuits, whatever their form or route, arrive at a substation for transformation of all or part of the energy which they carry.

The term "substation" suggests a collection of transformers, circuit breakers, regulators and a variety of smaller apparatus operating in con-

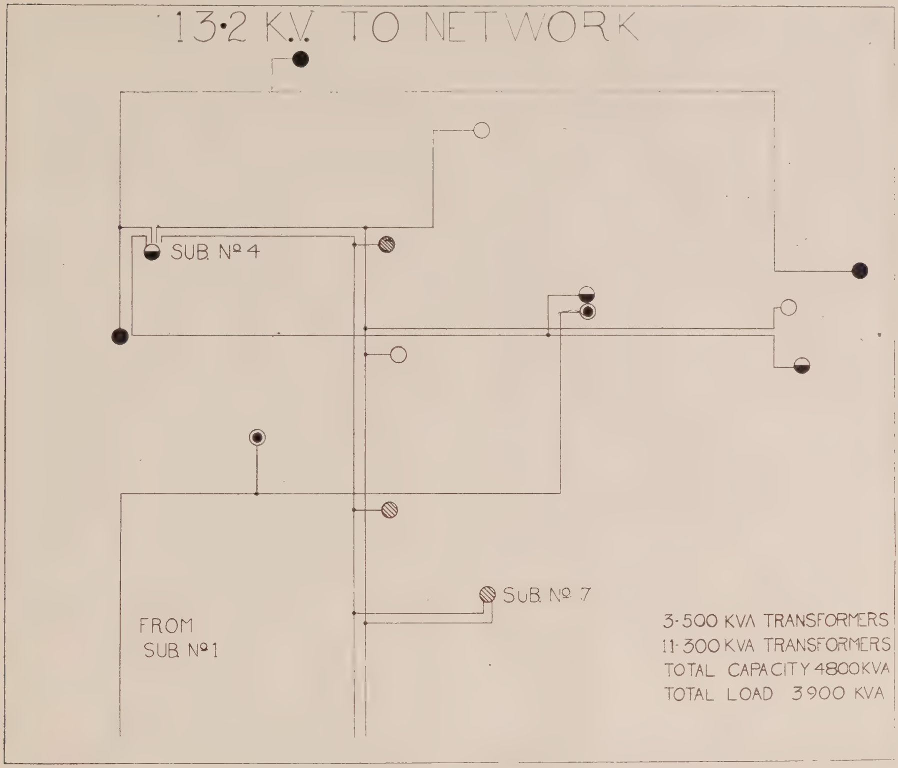


Diagram of 13.2 kv. lines to network system in London.

junction with a bus and switchboard. No doubt some substations deserve the criticism "too many eggs in one basket" and in some cases a substation represents one transformation too many. Elaborate and costly switching arrangements raise a question as to whether results as good or better could have been obtained from some alternative method. Is the substation and the equipment in the substation justified either on the grounds of better service, better voltage or economy? The growing use of the network, both primary and secondary, indicates a swing away from the old kind of substation, and while these network units will need to be backed up by some kind of a central point, its functions may be confined mostly to switching. Whatever its form or purpose, whether for transformation or switching or both, and whether new or rebuilt, modern metal clad breakers provide the streamlined effect which the old concrete bus and breaker structure lacked. The installation of today is compact and safe and offers a variety of switching arrangements, such as the transfer bus, if these are required. Where changed conditions have made necessary the replacement of old breakers with new or higher interrupting capacity, the metal clad have been particularly convenient because of space

limitations. In some cases instruments and relays have been mounted on the breakers and when reclosing mechanisms have been added, as for example on 4000-volt circuits in an unattended station, the result is a very compact and useful arrangement.

The use of underground cables may also be justified on primary lines for some little distance from the substation. This will eliminate congested poles with their usual hazards for men and service, and instead these circuits separate into their respective districts before going overhead. Thus the higher voltage lines, each of which serves many consumers and therefore creates a wide disturbance when trouble occurs, usually show considerable improvement when underground construction replaces overhead.

Underground lines are, of course, desirable and may even be essential in the main business districts of cities. These circuits include all voltages, and most, if not all, overhead lines are eliminated with improved service, safety and appearance as the result. While smaller cities may postpone this move, increasing loads will ultimately demand it and failure to provide for it in plans for the future may be costly.

Among the many items which may affect continuity of supply, probably none are more important than adequate maintenance. Regular inspection of both underground and overhead plant will reveal many things which are a reminder of the old admonition regarding a stitch in time. It may be a tree limb or a row of trees which are threatening a primary, or a collapsed joint in an underground cable; all of these are worth prompt attention. It is not necessary here to detail the possible hazards associated with transformers, circuit breakers and wire, but merely to stress the importance of care.

But trouble will arise sometimes, and then an alternative path or source is of tremendous help. In fact an arrangement of line disconnects, whereby a temporary feed may be obtained from another direction, may often facilitate maintenance and minimize planned interruptions. Of course the primary network is designed to provide these advantages but until the expenditures required by such a system are justified by the size and type of load, a very satisfactory and less costly alternative is possible. The transformer may be placed at the load centre, but without much of the auxiliary apparatus including circuit breakers, regulator and relays until such time as it may become desirable to tie these feeders with others in the district. In the interval, disconnecting switches provide the means of normal separate operation and sectionalizing and rerouting during emergencies.

Transformers placed in this way, of which the 13,200/4000 volt, 3 phase, 1500 kv-a. is a common type, may be located with regard to the needs of the present and without too much concern for the future. For, if conditions change and the load does not develop as expected, it is quite practical to move the transformer or unit substation to a more suitable spot. Probably it is fair to say that not much is known of long term planning

in any but the larger cities and even there some errors are almost inevitable. Therefore, any arrangement which permits an inexpensive change in the system to better serve changed load conditions will be a distinct advantage.

As progress gradually continues in effecting a change from the radial primary to the network, so will there be improvement in regulation and losses. There will be less danger of a large scale interruption, and costly commitments in substation buildings and equipment that might soon be obsolete, are avoided.

These advantages are, to some extent, duplicated in the low voltage network which is applicable in areas of high load density. Such a system has operated in London for about ten years with complete satisfaction. Prior to that time the main business section was served by two 4000 volt feeders from one substation. They were, for the most part, in cable, laid in ducts through the main streets to transformers in vaults, or on poles or on the ground in protected corners at the rear of buildings. From there large secondary cables, also in ducts, went to the consumers. So any one of a number of possible accidents might happen which might require a considerable amount of time to find and a longer time to repair. The effect of such an occurrence on the merchants was not pleasant to contemplate and it was decided that something should be done. The low voltage network was adopted and in addition to promising almost 100 per cent freedom from interruption, some ultimate economies in the reduction of losses and better regulation were realized. Savings in transformers, by reason of one transformation instead of two, may be largely absorbed by the protector which is an automatic low voltage switch. Network metering cost is considerably higher and of course, underground vaults, manholes, ducts and cables are costly though they are likely to be a part of any system in a heavy load district. The cost of the low voltage network as compared with any alternative system, will vary with local conditions but generally a load density of upwards of 20,000 kv-a. per square mile is considered sufficient to warrant the investment on the basis of results obtained.

The load density in London is over 30,000 kv-a. per square mile in an area of approximately ½ by ¼ mile. Fourteen transformers are in use, of 300 kv-a. each, except three of 500 kv-a. each. All are three phase units, 13,200/120-208 volts and usually with the protector mounted on the transformer tank. Insofar as is practical they are located at street intersections in sidewalk vaults; others are in substations, or on consumers' premises and one is on the ground surface in a suitable building on the market. They are fed from five 13 kv. feeders, three of which come from two substations, and two are taps from the original loop and main feeder system. The transformers are so connected on these five circuits that any one may be removed from operation without affecting the service to any consumer. Secondaries are mostly single conductor, 250,000 cir. mils lead covered cable, originally paper insulated and latterly asbestos. While some 500,000

cir. mils cable has been used, the smaller size burns clear more readily in the event of a breakdown in the insulation, and this is a feature of the networks designed to maintain service regardless of equipment failures. To date there have been no failures either in cables, transformers or protectors and the results have been entirely satisfactory.

While continuous service is of first importance in the consideration of any changes in the distribution system, yet other desirable results such as improved voltage and economies in operation are often associated with a reduction in interruptions. Such is the case with the networks, where distribution at a higher voltage and elimination of one transformation and banked transformers contribute to the aforementioned improvements. There is also the change which may only be desirable for good voltage and economy, without any promise of less interruptions. As an example there is the increase in primary voltage from 2300 to 4000 which produces beneficial results to voltage and economy without causing more interruptions. Another example of such a condition is the supply for the medium power load, usually at 550 volts. It has been common practice to group a number of customers on a 550 volt line which may grow to some considerable length and a substantial voltage drop. As an alternative, it appears quite feasible and economical to adopt a standard, 3 phase transformer, small, compact, of about 500 kv-a. size with cable in and out, which permits 13,000 volts to be carried to the premises of many power consumers. Transformer and cable failures are rare, and if such should occur, a reasonable interruption will permit a spare unit to be substituted. This plan was adopted in London after the 1937 flood which entered No. 1 substation. Several industries in the vicinity had been served at 550 volts from that point, and after the flood an alternative method was looked for to prevent a similar interruption again. These factories were on higher ground than the substation and their loads and locations were such that it was possible to standardize on a 500 kv-a. unit. Since that time several more of the same size and type have been put in service in other parts of the city.

A number of municipalities have recently installed equipment for the control of water heaters. This has proven to be a sound investment, not only because of a saving in the cost of power but more particularly because the lower peak load requires less investment in transformers and wire, etc. And it may be further claimed as an advantage for this control that as the load factor improves voltage becomes better. The control may even be given credit for avoiding some interruptions which would otherwise be caused by the "blowing" of transformer fuses. Many improvements made originally in the name of one objective, may later appear as a credit in three columns—interruptions, voltage and economy.

Joint lines with the Bell Telephone Co. or other utility may be adopted for one or more of the above reasons, and, of course, improved appearance of the street is usually a result. It

has proven a most useful arrangement in recent years, particuarly at a time when the original Hydro poles were due and perhaps overdue, for replacement. As either party made plans for replacements or changes on any street, the other party was notified, with the result that it was usually possible to do the work jointly and eliminate one pole line. Rebuilding and maintenance expense has been reduced for both parties and the public has welcomed the elimination of one pole line on each street.

Street lighting cannot be said to have kept pace with the needs of increased traffic except possibly on a few main streets. This has probably been the case in every municipality, although students of accident prevention claim that such a policy is not in the interests of economy. There will be plenty of room for improvement in this phase of utility operations for years to come. In the meantime, some attention is being given to the economies and improved service to be effected in a change from series to multiple lighting. The higher voltage system has long been a source of trouble and danger to linemen in bad weather and in recent years radio interference has been often traced to it. While granting the advantage of a constant current system with a longer life lamp, yet the less costly lamp operating on transformers erected primarily for domestic use and whose load factor the street lamp improves, is winning support. The control of multiple lamps is no longer a problem, when relays are lightly loaded. A small load per relay avoids pitted contacts and voltage drop is negligible.

Quality service may require voltage regulators although they are often omitted either because little improvement is possible or because the local authorities are not convinced that the results would warrant the expense. The H.E.P.C. operates a large condenser in the London station and the voltage as supplied to the city is very good. It was possible some years ago to abandon all induction regulators, although some operating difficulties with single phase, 25 cycle regulators on 4000 volt circuits contributed to this decision. The improvement in voltage resulting from the control of water heaters, which was mentioned before, was measured on one consumer's premises at about 2 volts. However, the voltage regulator is and will continue to be a most useful piece of apparatus, particularly since it appears that people are demanding better voltage as they purchase more appliances for the home. It has occurred to us that their criticism may often be inspired by lamp, radio or gas salesmen who are endeavouring to escape from their own responsibilities. This may remind you of the "pot calling the kettle black," but without wishing you to say "methinks he protesteth too much", I wish to repeat that London voltage is good without regulators.

Distribution transformers and secondaries offer a good field for the improvement of losses and regulation. Unsatisfactory conditions can probably be substantially improved by attention to this part of the system and it may be that many municipalities in Ontario are suffering from transformer sizes and spacings, and wire

sizes which are not best adapted to the load density. The following figures illustrate this; they were prepared in London a few years ago based on conditions existing there at that time and for an average load density of 10 amperes per 100 ft.

Transformer and Copper Size	Regulation	Energy Loss	Annual Cost per kv-a.
40 kv-a.— 90 M. cir. mils	6.2%	4.7%	$2.78
40 " —180 "	3.1	2.4	2.34
20 " — 90 "	1.5	1.8	1.98

The cost includes interest and depreciation and energy loss. The range considered was from a typical light load area of 7 amperes per 100 ft. to a typical first class residential area of 13 amperes per 100 ft. In the former case 60,000 cir. mils and a 15 kv-a. transformer was found most suitable and in the latter 90,000 cir. mils and a 25 kv-a. transformer. The result was that the usual transformer size purchased was changed from 37½ to 25 kv-a. with an occasional smaller size. Existing wire sizes were generally satisfactory.

The investment in the secondary distribution system is a large percentage of the total and there is need for sound, economical design to produce the best results for both the consumer and the utility. Likewise, losses in the secondaries may be a large part of the total and substantial improvements may be possible. Variations in load density from street to street or from district to district require somewhat different transformer and wire sizes. This is more pronounced in the large city where apartment and duplex houses raise the load density considerably. Transformers have not been banked to any extent except where load densities are high. Possible improvements in service from this arrangements have not been sufficient to warrant the precautions necessary in the event of a transformer failure. Some transformers were banked in London in the early Hydro days, but so much difficulty was experienced in restoring service after trouble had occurred that the scheme was abandoned. The arrangement is recognized, however, as very useful where loads are heavy and with proper fusing.

Services have received some attention in recent years but satisfactory results have not yet been achieved. The original open wire service is again being used, although cable was adopted for some time. The wire to the house and into the house, the location of the meter, and the policy with respect to ownership as between the consumer and the utility are questions linked together. It is the point in the system where the utility meets the consumer and the private contractor, and satisfactory results are not always obtained.

Meters have reached a high state of perfection, and when a high bill complaint is received the meter could be correctly exonerated in almost every

case. Over a wide load range and in widely varying temperature, the modern meter continues to register correctly. John Smith can be assured that the total consumption is being fairly divided between him and his neighbors and all consumers. So confident of their product have the manufacturers become, that they are now bringing it out of the dark cellar and putting it in the daylight. The advantages claimed for the outdoor meter are the saving of meter readers' time, and theft prevention. Many utilities feel that their water meter inside requires the reader to go in and therefore eliminates the saving, and, secondly, theft is only present in rare cases under existing conditions.

From the point where delivery is accepted from the H.E.P.C. to the consumer's meter, many improvements in apparatus and methods have been made. This has permitted service to become better and better, keeping pace with the demands of new appliances. Interruptions are now rare and of short duration; voltage is generally good; economy has been the watchword. In conclusion, there should be a word of caution. The satisfactory condition of a utility today will not be so tomorrow unless a constant effort is put forth to improve. Maintenance must be continued, obsolete equipment must be replaced, and new equipment adopted as the need is indicated.

System Loads in September

THE system loads of The Hydro-Electric Power Commission of Ontario record an increase in primary loads in September, 1940, of 12.3 per cent over those of September, 1939. This increase which is a little less than that of August, 14 per cent, was due chiefly to further load growth in the Niagara system, Eastern Ontario system and Northern Ontario Properties. In the Niagara system there is a slight falling off, the increase being 13.4 per cent compared with 15 per cent in August. The same falling off is shown in the Eastern Ontario system, the August increase being 11.2 per cent, while that of September was 9.9 per cent. Northern Ontario Properties' load increase was greater in September than in August, last month being 17.6 per cent, while the previous month was 15.3 per cent.

Georgian Bay system while showing a small increase, 2 per cent, compared with zero in July and 2.4 per cent in August, reflects the saving that can be made in bulk power supply by the adoption of daylight saving time in parts of the area served. In 1940, twelve municipalities adopted daylight saving time. This advanced the time of the municipal peaks in those towns one hour, with the result that although there is a substantial growth in the individual municipal loads, the diversity caused by chang-

ing the times of the peak loads in those twelve municipalities has been sufficient to permit serving the whole system with but small increase in system load. In one month the system was saved over 5,000 horse-power.

In the Thunder Bay system a decrease of 2.4 per cent is shown in September, while in August there was an increase of 9.7 per cent. This changed condition is due to grain elevator load at Fort William and Port Arthur. A year ago there was a heavy grain movement in September on account of the war having just started. This year the grain is being held in the elevators with the result that there is a considerable reduction in the amount of power required for the handling of the grain which is reflcted in the system load.

The tabulation of the system loads for the month of September is as follows:

System	Maximum 20-Minute Peak H.P.		Percent Increase
	September 1940	September 1939	
Primary Loads			
Niagara	1,249,597	1,101,474	+13.4
Eastern Ontario	155,174	141,201	+ 9.9
Georgian Bay	37,269	36,536	+ 2.0
Thunday Bay	96,515	98,934	— 2.4
Northern Ontario Properties	194,244	165,124	+17.6
Total of All Systems	1,732,799	1,543,269	+12.3
Primary and Secondary Loads			
Niagara	1,412,332	1,317,828	+ 7.2
Eastern Ontario	155,496	173,520	—10.4
Georgian Bay	37,269	36,536	+ 2.0
Thunday Bay	96,515	131,917	—26.8
Northern Ontario Properties	226,549	213,382	+ 6.2
Total of All Systems	1,928,161	1,873,183	+ 2.9

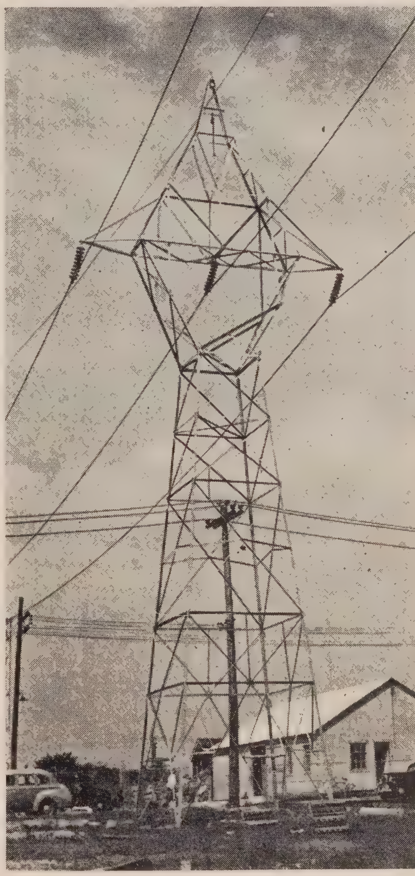
Spire-Type, Single-Circuit Steel Towers

Supporting 110,000-Volt Transmission Line

By A. E. Davison, Transmission Engineer, H.E.P.C. of Ontario

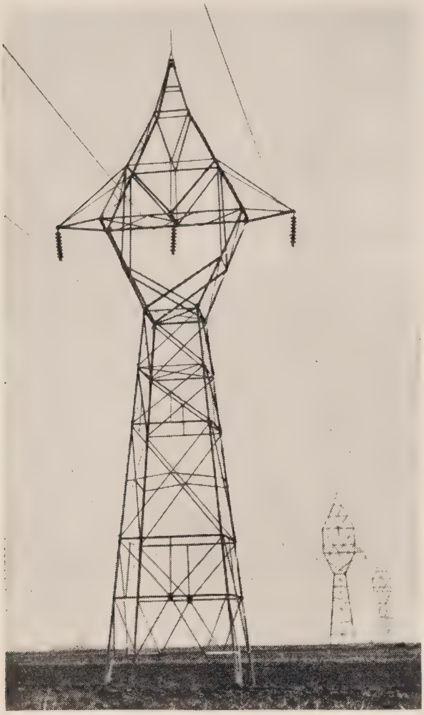
STEEL tower designers have, for a number of years, tried to provide adequate radial clearances for swaying electrical conductors. Some of the more important clearances are those between conductors in horizontal layers, those between conductors in vertical layers, and the offsetting of conductors in one layer so that they will not be in a vertical plane with conductors above or below. Typical vertical separations during the past 30 years have ranged from 7 feet to 13 feet.

Operating experience along the Atlantic seaboard, along the Niagara river and elsewhere has indicated that much greater separation is needed if short circuits and arcs to ground are to be avoided while ice-laden conductors and ground cables are moving about in the span asynchronously as a result of the action of moderate winds upon them. Since the movements of these conductors usually have greater vertical than horizontal dimensions, then, always excepting the use of lower mechanical tensions and shorter spans, increasing the vertical clearances would seem to be the safest, although not necessarily the most economical, way of assuring service security.



Spire-type, 110 kv., single circuit structure complete with elevated ground cable.

Increased separation between a layer of power phases and the overbuilt sky or ground cable improves service security in two ways, viz., by improving the protection against



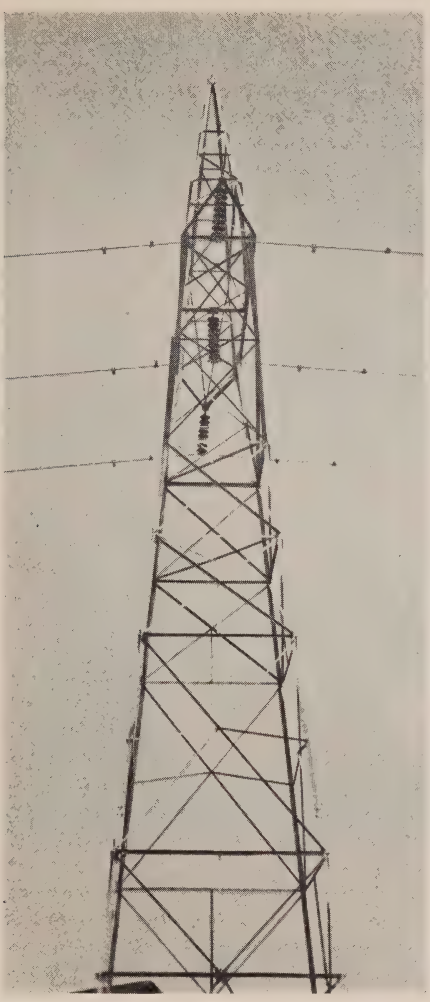
"1940" experimental installation, standard and transpositional towers without ground cable.

Double-circuit, 110 kv. lines operating St. Thomas to Windsor, 1915 to 1940. Interruptions from all causes of about two per year. Reasons for some of these interruptions are evident.

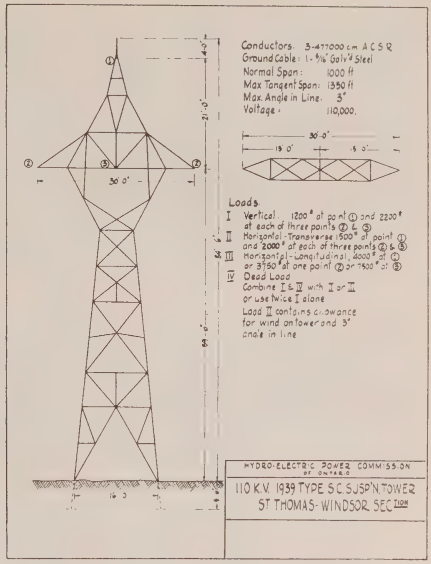
lightning, and by reducing to a minimum, electrical faults caused by galloping. C. F. Wagner and his associates at the Swampscott (Mass.) meeting of the A.I.E.E., June, 1940, have recorded probably the latest information on the effectiveness of the height of ground cables above power cables in protecting the latter from flashovers due to lightning.

A new transmission structure, the design of which was decided upon in July, 1939, has been operating at 110 kv. for some time in western Ontario. The receiver terminal is at Windsor on the Detroit river. The location of the proposed 5/16 in. ground cable is directly over the middle of three power conductors which are horizontally spaced some 15 feet apart. The vertical separation is 25 feet, being just about twice that used in most designs during the past thirty years.

The accompanying illustrations indicate the appearance of the structure in the field. They also indicate that new torsional types of vibration absorbers are installed, in some cases two and in other cases four per span.



Spire-type construction (side view) with torsional absorbers installed.



Clearance and loading diagram of a single circuit suspension tower.

A diagram is submitted illustrating some of the clearances. Standard spans are of the order of 1,000 feet, using 447,000 cir. mils a.c.s.r. "Hawk" conductor.

In the region in which the lines discussed herein are situated, isoceraunic data issued by the Weather Bureau indicate that about forty lightning storms per annum may be expected. The transmission line lies, if anything, along rather than across most storm paths. More orthodox types of transmission lines (see illustrations) have operated quite successfully in this area for periods of from 26 to 30 years without either special grounding of steel towers—typically 20 ohms, with some areas averaging 40 ohms per tower—or counterpoise facilities. Outages of these older lines due to lightning are of the order of 0.8 per 100 circuit miles per annum. Interruptions from all causes to the electric services supplied through these older lines averaged less than two per year and less than 10 minutes per year during 10-year periods. These interruptions resulted from outages within a large transmission and generation system of which the 200 circuit miles re-

ferred to are only one important part. In order to study the economics and service securities of ground cables and of high-speed automatic circuit breakers controlling transmission lines in flat clay country, a ground cable has not been used on the new line for the time being. Experience with the new circuit during one lightning season would indicate that ground cables are desirable additions to lines of this type, even after they have been equipped with high-speed circuit breakers.

The Hydro tent at the Plowing Match.

The International Plowing Match

THE International Plowing Match and Farm Machinery Demonstration of the Ontario Plowmen's Association was held this year October 15th to 18th inclusive on the Ontario Hospital Farm at St. Thomas and adjacent farms including the Bannockburn Farms of Premier Hepburn.

The lay-out of the tented area and plowing contests was ideal in that all plowing contests and demonstrations were within easy walking distance of headquarters, with the result that there was an excellent attendance at all the competitions.

This was the most successful match in the history of the Association, there being a very substantial increase in the number of exhibitors as compared with previous years and the attendance for the four days was esti-

Part of the Hydro display showing household equipment. Lighting was by means of "PAR 38", 150 watt lamps in groups of four erected on the three tent poles

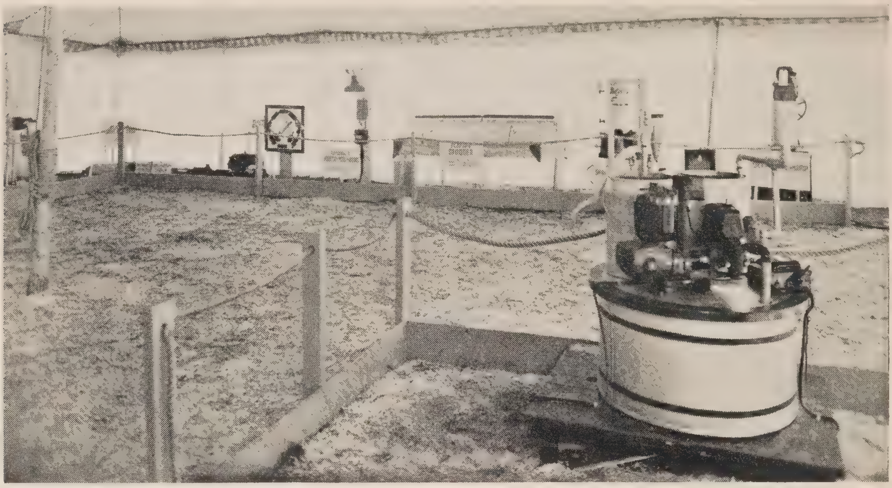
mated at from 170,000 to 195,000. The entries in the plowing contests totalled 904, this being an increase of 223 over the previous record.

The concession area covered 12.5 acres of land and provided 4500 feet of frontage for exhibits. The electrical distribution system required 2500 feet of three-wire, secondary bus serving 70 exhibitors with a load of 80.5 kw. The water system required the installation of approximately 3000 feet of piping, the supply being obtained from two sand points installed adjacent to the grounds by the local committee. An average of 5,000 gallons per day was pumped from the well.

One of the interesting features of the match was provided by the Royal Canadian Air Force, who had on display the Battle I. single engined monoplane bomber, which had seen service in France in the early days of the present war.

On Friday afternoon the Royal

The dairy display included refrigerators, milk coolers and pasteurizers, milking machines and cream separators.



Display showing soil heating, poultry farming and water pumping equipment. The set-up in the foreground is a hand pump and an electric pump, rated 320 gallons per hour, where visitors were given the opportunity of endeavouring to fill a five gallon container by hand in competition with the electric pump.

Canadian Air Force from the Technical Training School at St. Thomas paraded approximately 3000 strong through the grounds, the salute being taken by the Honourabe M. F. Hepburn, Premier of Ontario.

The Hydro-Electric Power Commission's trophy, consisting of ½ horse-

A part of the crowd as seen from the entrance to the Hydro tent.

Explanitory display of essentials to give rural electric service from the distribution line to the consumer's wiring. At the right rear is a bicycle arranged with an electric generator, meters and lamp load where visitors could test their power to produce electricity.

power motor as first prize in Class 7, was won by Russell Morrison of Beaverton.

The Hydro-Electric Power Commission's exhibit was housed in a large tent and the following representative pieces of merchandise for the home were exhibited:

A deluxe model electric range, a low priced electric range and a rangette requiring no special wiring, a humidifier, refrigerator, Hydro flat rate water heater, washing machine, ironing machine, radio, a combination fast freezer and domestic refrigerator operated from the one unit, and a complete assortment of miscellaneous small appliances.

In the barn section were a grain grinder, electric milk pasteurizer and cooling equipment, electric milking machine, electric separator and electric milk cooler, electric pail, soil heating cable display, an assortment of electric motors, poultry lighting, electric poultry brooder, shallow-well pump and a deep well pump.

There was also a most interesting exhibit consisting of a hand pump and an electric pump of approximately the same pumping capacity. These were mounted together on a display stand and the visitors to the tent were asked to equal the work of the electric pump by filling in competition with it a 5-gallon container. Many tried but very few succeeded.

There was also supplied a stationary mounted bicycle, the rear wheel of which was in contact with a pulley on a generator. When the bicycle was pedalled the power was transmitted and shown visually on metering equipment and on lighted bulbs. The visitors were requested to mount the bicycle and pedal same to generate the necessary current to light a 100 watt bulb for 60 seconds. The best record was performed by one young lad who pedalled for 30 seconds and was exhausted. Both this display and the pump convincingly proved to many of the contestants and on-lookers the value of electric power in doing much of our manual work.

220-Kv. Power Supply from Quebec Border to Burlington

IN order that the balance of the power contracted for from the province of Quebec may be transmitted to the highly industrialized sections of this province, it is necessary that additional transmission line and transformation facilities be provided to utilize to the fullest extent this additional reserve of electrical energy.

At the present time, the 25-cycle power purchased from Quebec, together with the capacity of the Chats Falls plant owned by this Commission, is transmitted by means of three single-circuit, 220,000-volt lines to Leaside, where a station has been established for a number of years, stepping down to 110,000 volts for the purpose of serving the existing 110,000-volt transmission line system of the Commission, together with supplying 13,200-volt power to the city of Toronto and vicinity.

After a careful study of this problem, it has been decided that the proper location to feed into the Commission's 110,000-volt network would be in the vicinity of Burlington, this point being an important load centre, as well as the section of the province where most of the present 110,000-volt lines radiating from Niagara Falls to western Ontario and Toronto, may be readily intercepted.

The present program calls for construction of a line from the Quebec border to Burlington, having a length of approximately 282 miles, 46 miles of which will be double circuit, the double circuit being the section between Leaside and Burlington. The proposed line will have a capacity of 200,000 horsepower and in its construction, will require approximately 11,300 tons of steel and 3,600 tons of conductor. The towers will have a spacing of approximately 1,150 feet, and will use aluminum conductor from the Quebec border to Leaside, with hollow copper conductor from Leaside to Burlington, copper being used in this section due to the present curtailment on the use of aluminum. Construction was started on this line in May, 1940, 65 miles of towers being completed on September 9, 1940, and it is expected that the completion will be about June 1, 1941.

It is interesting to note that in construction of this line, some 700 men are now employed.

At Burlington, provision is being made to install two banks of three 25,000 kv-a. transformers. This will give a total capacity of 150,000 kv-a. or approximately 200,000 horsepower. Transformation will be made from 220,000 volts to 110,000 volts, with no provision for either 13,200 or 26,400 volts on these transformers.

The rapidly expanding municipal and munition loads in the Niagara peninsula and western Ontario, make it necessary that this station be placed in service at the earliest possible date.

Instruments in Science and Industry

By Robert S. Whipple

(*Continued from September*)

Perhaps there is no instrument which in recent times has aided pure science so much, and which is now beginning to help industry, as the spectroscope. Fraunhofer constructed the first spectroscope in 1817, and made the first measurements of the lines of the solar spectrum. He was also the first to observe the spectrum of the electric spark. In 1842, Becquerel and Draper independently photographed the solar spectrum on Daguerreotype plates, thus laying the foundation for the modern science of spectroscopy. In 1859, Kirchhoff showed that the luminous vapour of a metal has the property of absorbing the same kind of light as it emits at the same temperature. Kirchhoff recognised the fundamental importance of his discovery, entitling it "Spectrum Analysis"; but it is largely due to Hartley (1882) and later to Twyman, who designed simple and efficient instruments, that spectroscopic analysis has become a quantitative method of chemical analysis. The spectrograph is now one of the most important tools in the metallurgical and chemical laboratory.

Our knowledge of the constitution of the celestial bodies is almost entirely due to the spectroscope. By its means it has been possible to discover what elements are present in the vapour surrounding them. The major part of the knowledge obtained about the double stars and also the determination of the velocity of stars in the line of sight has been obtained from spectroscopic observations. The theory of the expanding universe may be said to rest on spectroscopic observations. In theoretical physics the value of spectroscopic work cannot be exaggerated; it is, I understand, true to say that modern theories of atomic structure depend largely on evidence supplied by the spectroscope. Unfortunately, there is no time to dwell on the comparatively new development of the X-ray spectroscope and the importance of this instrument in chemical analysis and in the understanding of the structure and behaviour of alloys.

The distinction between the telescope suitably mounted to survey the heavens and that used to measure distances upon the earth's surface is a faint one. The transit instrument is, in general, only a larger form of theodolite. The early surveyors (and here we may go back to early Egyptian times) made plans by means of rods and plummets; but it was not until the invention of the astrolabe and the use of a divided circle fitted with sights that accurate surveying was attempted. The first mention of the word "theodolite" occurs in a book *Pantometria* (1571) by an Englishman, Thomas Digges. (It is a matter

of interest that Digges has some claim to be called "the inventor of the telescope.") The early theodolites, like the astronomical instruments, were fitted with pin-hole sights; in the case of the latter instruments an important controversy arose between Hooke and Hevelius (1679) concerning the relative advantages of telescopic and open sights. Although Hevelius was not convinced, the telescopic sight was almost invariably used after that date. Mention should be made that William Gascoigne invented the filar micrometer and fitted it to a telescope in 1640: this invention greatly increased the accuracy of instruments to which it was attached. Bradley's observation in 1722 shows that he used a form of filar micrometer with considerable success.

As the demands of the astronomer, and later of the surveyer, increased, so the need for improved divided circles has always been one of the more difficult tasks of the instrument maker, and it is almost entirely due to the English manufacturer that the art of dividing has reached its present high position. For many years there was no alternative but patiently to bisect, or trisect, with a beam compass, the spaces set out on the scale or circle, and to continue this operation until the scale was subdivided to the desired number of divisions. The master points controlling the dividing can even now be seen on some of the old instruments. The names of George Graham (1673-1751) and John Bird (1709-1776) may be mentioned as masters of the art; it is stated that Bird was able to obtain an accuracy of 5 minutes of arc on his 8-ft. quadrant by continued bisection of the arc.

Henry Hindley, of York, about 1739, completed a small machine for cutting the teeth in clock wheels and for dividing instruments. In 1766, Jesse Ramsden made his first circular dividing engine, but as it was not sufficiently accurate for dividing the scales of nautical instruments, he completed a second machine in 1775. In 1826, William Simms invented the self-acting mechanism by means of which the dividing machine became completely automatic, thus saving an immense amount of time, and reducing the risk of error in the dividing of a circle. Linear scales are automatically divided by somewhat similar machines in which are fitted a temperature-compensation device for variation in the temperature of the machine and a compensation device for correcting for any variations in the pitch of the master screw. In this connection, the scientific man and the instrument maker are alike indebted to the late Dr. C. Guillaume for the invention of Invar, a nickel-steel alloy having a remarkably small temperature coefficient of expansion, and hence an almost ideal material from which to manufacture standard scales and measuring tapes.

An interesting development in surveying instruments has taken place during the last few years. Heinrich Wild, a Swiss engineer, designed, about 1921, a theodolite in which, by means of an ingenious optical system, it is possible to read the positions of the vertical and azimuth circles simultaneously in the eyepiece of a microscope mounted on the same axis as the telescope.

Before leaving surveying instruments mention must be made of the new developments in aerial surveying in which the contours, etc., are obtained from photographs taken from aircraft at different standpoints. Although surveying by photography had been used before the Great War for the mapping of districts difficult to survey by ordinary methods, yet it was not then generally employed. Improvements in photography from the air, especially in the development of wide-angle flat-field photographic lenses having negligible distortion up to an included angle of 90 deg., have made it economically possible to survey fresh country, and even to check over surveys that have been previously made by the usual methods.

The earliest of all instruments were, however, those devoted to the measurement of time, and depended on the position of the sun; in the majority of cases on the position of a shadow cast by it. Later the time was also told by observing the position of the earth relative to the stars. Throughout the Middle Ages, and later during the Fifteenth to Seventeenth Centuries, great ingenuity was shown in the design and construction of sundials and nocturnals. The large literature on the subject shows how important the measurement of time was, even then, to the community. For the purpose of our discussion, we need not dwell further upon these instruments nor upon the clocks used previously to the invention of the pendulum. Although Galileo had noticed in 1581 that the time of swing of a pendulum was almost independent of the amplitude of its swing, yet it is doubtful whether he succeeded in making a working clock. In 1657, Huyghens patented his pendulum clock, and described it fully in 1673 in his *Harologium Oscillatorium.* The clock was driven by a falling weight and kept the pendulum in motion by impulses transmitted through a verge escapement. Shortly after this date Hooke invented the anchor escapement, which, in its form modified by Graham, became the escapement used in the majority of pendlum clocks, and remains so to the present day. The effect of temperature upon a pendulum clock is serious, in that the length of the pendulum varies with temperature and hence the duration of the period of swing. Graham, in 1721, introduced a pendulum bob containing mercury; thus, by adjusting the quantity of mercury its expansion could be made to counteract that of the steel pendulum rod. Five years later Harrison invented the composite, or "grid-iron", form of pendulum made of brass and steel rods to which the weight was attached. Nearly all the temperature-compensation difficulties disappeared with the invention of Invar.

The accurate control of the length of the wireless waves radiated by the broadcasting station has been a difficult problem, and has resulted in the production of an extremely accurate timekeeper. That certain asymmetric crystals when subjected to electrical stresses change their dimensions was discovered by the brothers J. and P. Curie in 1880. They also showed that such crystals develop surface charges under the influence of mechanical pressure. Later it was shown

that when stressed by a rapidly alternating current the crystal is made to vibrate, and if the frequency agrees with the natural frequency of the crystal the amplitude of oscillation is relatively large. Primarly owing to the work of two men, W. G. Cady in America and the late D. W. Dye in this country (Great Britain), quartz-crystal controlled oscillators have been developed which maintain themselves in oscillation at a definite frequency and with an accuracy of approximately one part in one hundred millions.

From the point of view of industry, the thermometer is one of the most important of all scientific tools, for that is its ultimate position. The first instrument for measuring temperatures was an air-thermometer, and was invented by Galileo about 1592. His friend Sanctorius actually used a form of thermoscope to show variations in the heat of the human body—the first clinical thermometer. The Grand Duke Ferdinand II of Tuscany is said to have invented, about 1650, the first alcohol thermometer in which the tube was hermetically sealed. It is not known to whom the invention of the mercury-in-glass thermometer is due, although it was in existence in 1693. Lord Kelvin propounded the thermodynamic scale of temperature as the final standard of reference, and it is to this scale (the absolute scale of temperature) that all temperatures are now referred.

Electrical methods of measuring temperature have made great strides during the past few years. A great deal of this progress was due to the work of H. L. Callendar, who was President of Section A when the British Association last met in Dundee in 1912. He showed that the resistance thermometer suggested by Sir William Siemens in 1871 could be made an instrument of high precision, and at the same time developed simple bridge methods for measuring the resistance of the thermometer. Above all, he invented the Callendar Recorder, the pioneer of the majority of recording bridges and potentiometers in use to-day.

The discovery of thermo-electricity by Seebeck in 1822 led eventually to the production of the simplest electrical thermometer and one of the most practical in industry. The platinum-platinum 10 per cent. rhodium couple was introduced by Le Chatelier in 1886, and owing to its reliability and to the fact that its electrical constants can be reproduced in various meltings of the alloy, has become the most generally used in accurate high-temperature work.

A variety of potentiometers, deflection galvanometers and recorders have been developed to meet the demands of industrial thermometry. The application of high temperatures in industry, especially in metallurgical work, has increased the demand for instruments capable of measuring temperature without being placed in the hot zone. The first satisfactory attempt at such a pyrometer was made in 1892 by Le Chatelier. In this instrument, which was a form of photometer, the intensity of the light received from the hot body was adjusted by means of an iris diaphragm (later by means of absorbing-glass wedges) to match that given by a standard lamp. A few years later Holborn and

Kurlbaum introduced the disappearing-filament form of instrument which, in one form or another, is now the most generally used type of optical pyrometer. In this the filament of a small incandescent lamp is interposed between the eye of the observer and the hot body. The current through the lamp is adjusted so that the filament becomes invisible against the incandescent hot body. The Fery pyrometer (1902) consists of a thermocouple of small mass mounted in the focus of a concave mirror, which focuses the total radiation received from the hot body on to the couple. This instrument can be used to measure temperatures throughout a large range. It has also the advantage that it can be readily attached to a recording galvanometer and can thus be made to follow the stages in the heat treatment of materials in a furnace or kiln.

The last instrument that I shall deal with is the galvanometer, and that can only be taken as representing the great group of electrical instruments that has come into existence during the past century. The name itself was given to a form of electrometer by Bischoff in 1802, and commemorates the discovery by Galvani of the movements of the muscle of a dead frog by electricity. Oersted, in 1820, discovered that an electric current would deflect a compass needle, and thus laid the foundation for the many types of moving-iron or magnet galvanometers. In 1858, W. Thomson (Lord Kelvin) invented the mirror galvanometer for use with the Atlantic submarine cable; this instrument made submarine signalling possible. In 1881, the Deprez-d'Arsonval moving-coil galvanometer was invented, and, although it had been anticipated by other inventors, the credit is due to these two distinguished Frenchmen for the most practical form of galvanometer—the one used in practically every direct-current measurement. The moving-coil galvanometer has been studied theoretically and practically by Ayrton and Mather, Zarnicke and Moll, and the result of their work is an instrument of extremely high sensitivity and short period. Paschen, Nichols and Downing, and Hill have done much to increase the sensitivity of the moving-magnet galvanometer. In this connection acknowledgment must be made of the great debt the physicist and the instrument maker owe to that doyen of instrument designers, Sir C. Vernon Boys. The high sensitivity of certain types of galvanometer is very largely due to his invention of the quartz fibre—the ideal material for suspending light bodies.

A form of galvanometer which has proved of great service in industry in confirming much theoretical work in connection with alternating currents is the electro-magnetic oscillograph, a galvanometer possessing an extremely short periodic time and fairly high current sensitivity. The moving-strip type, in which the element is reduced to the simplest form, consists of a loop of a fine metallic strip stretched in a magnetic field, the air-gap being reduced to a minimum. This instrument was invented by Blondel in 1893, but its development was largely due to Duddell, who, six years later, showed in a series of striking experiments

the possibilities of the instrument. Since then its capabilities have been much improved, the latest models having a natural frequency in air of 1/17,000th second, and a sensitivity of 42 mm. at one metre for 0.1 ampere direct-current, or with a frequency of 1/3,000th second a sensitivity of 580 mm. at one metre for the same current—a sensitivity ten times that possible five years ago. Many of the phenomena to be studied take place in such short intervals of time (0.000001 second to 0.00000001 second) that it is impossible for any form of mechanical instrument to respond. This has brought into general use the cathode-ray oscillograph. The cathode-ray beam is deflected by the current or voltage under investigation, the movements being recorded either by the direct action of the beam on a photographic plate, or by photographing the luminous trace on a fluorescent screen. For the observation of phenomena occurring in extremely short intervals of time the former method is adopted, the writing speed of the spot being approximately one-third the velocity of light.

An address of this nature would be incomplete if no mention were made of the thermionic valve. Its advent has led not only to the birth of a wide range of new instruments otherwise impracticable, but also to the simplification of many measuring techniques. The thermionic voltmeter was one of the first, if not the first, measuring instrument employing a valve directly and using to the full its most valuable characteristics as a measuring device. These characteristics may be briefly summed up as rectification, amplification rapidity of response, and high impedance. Although these are the prime considerations, others, such as high overload capacity are advantageous.

The demand for instruments is ever growing. As new problems arise, both in science and industry, the requirements become more stringent. The instrument maker constantly receives incentives to progress from the scientific worker to whom he owes not only suggestions but many of his new materials. It is, I suppose, a truism that if knowledge is to progress it is essential that theory and practice advance together. Nowhere is this more true than in the development of scientific instruments.—*Engineering.*

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Toronto-Fairbank Transformer Station

By S. A. Perrot, Electrical Engineering Department,
H.E.P.C. of Ontario

ON September the 8th, 1940, an important addition was made to the several transformer stations feeding Toronto and its vicinity, when the Toronto-Fairbank transformer station was placed in service. The station is now supplying power to the new Glencairn distributing station, Forest Hill municipal station and stations on north Yonge street, formerly supplied from Leaside transformer station. The six new unit type distributing stations now being constructed in York township and the Weston municipal stations will be added later on in the year.

The load growth in the areas of Peel and York counties, particularly north and west of the city of Toronto, reached such a point in 1939, that the existing transmission facilities were found inadequate to give satisfactory service to the municipalities and customers in this area. Studies were made of the situation, which revealed the fact that the distribution of power at 13,200 volts was no longer feasible. This, together with the semi-urban loads adjacent to the city of Toronto, made it advisable to establish a new 110 kv. transformer station north and west of Toronto which would distribute power at 26,400 volts. The construction of the Fairbank station has taken these facts into consideration, and the general policy in future is that all stations adjacent to the city of Toronto will distribute 26,400 volt power to the areas in question.

Taking cognizance of the present conditions as well as of the future prospects, a station with an ultimate capacity of 100,000 kv-a. was required. The choice of the Fairbank site on Roselawn avenue near the Belt

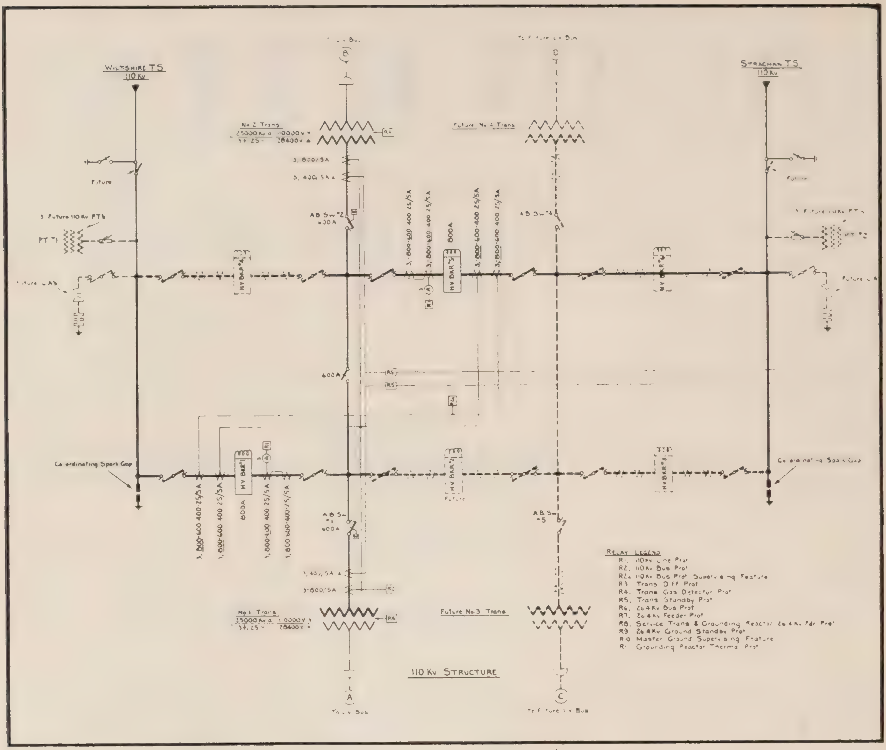

Fig. 1.—Wiring diagram of 110 kv. section.

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November, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

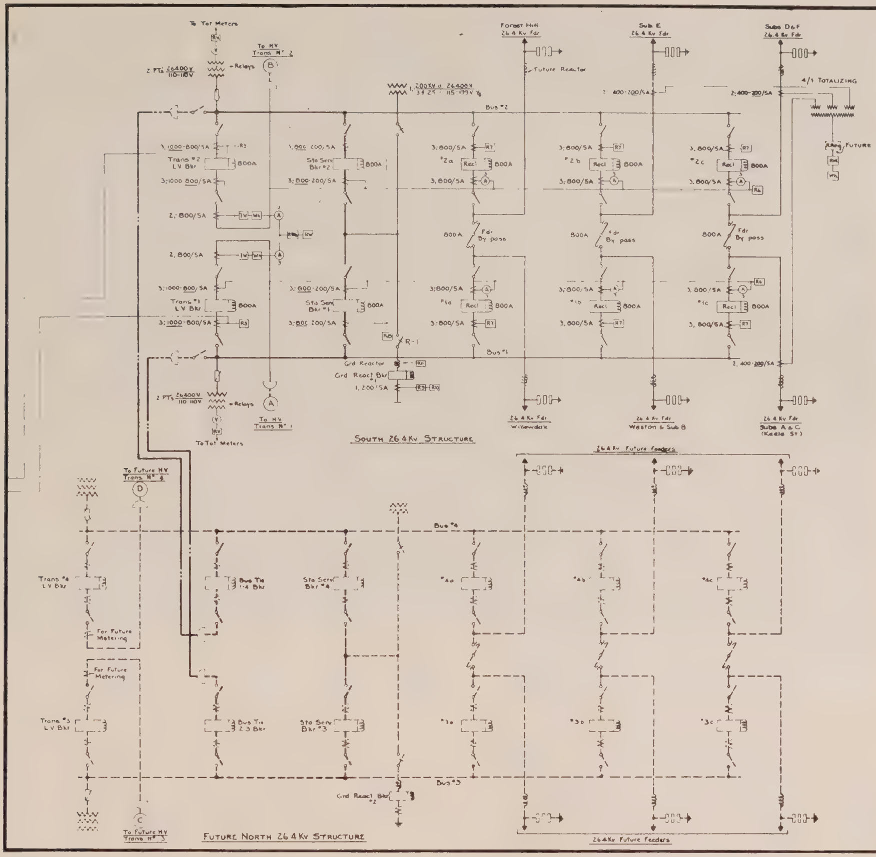
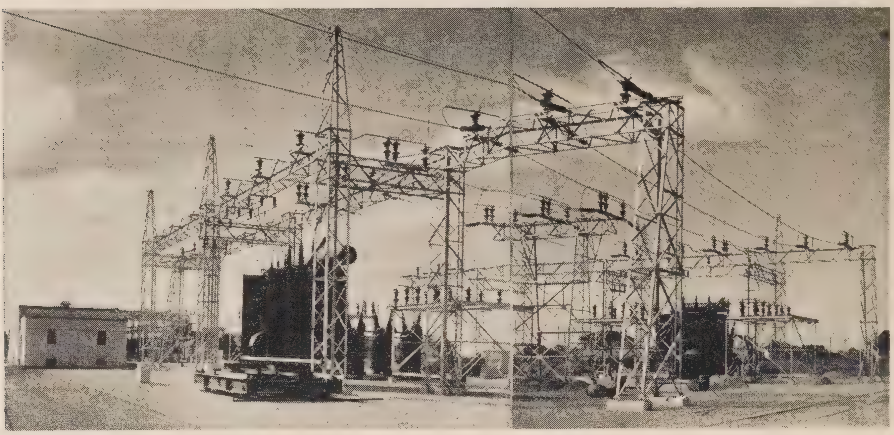


Fig. 2.—26.4 kv. wiring diagram.

Line railway and near the centre of gravity of load, also offered reasonable approaches for the loop connection to the 110 kv. line between Wiltshire and Strachan avenue transformer stations.

Figs. 1 and 2 show a single-line diagram of the station, with the present and future parts shown in full and dotted respectively. The final installation will consist of a 110 kv. ringbus supplying the power through four 25,000 kv-a., 3 phase, 110 Y/28.4-14.2 delta kv., 25 cycle, oil insulated, forced air cooled transformers to two 26 kv. bus and switch structures, each having provision for six outgoing 26 kv. feeders. Fifty per cent of the station capacity was installed initially, and includes one 26 kv. structure and the two 25,000 kv-a. power transformers feeding this structure. In order to bring in the two 110 kv. lines, it was necessary to complete the high-voltage section of the layout with the exception of some minor switch structures. The ring bus, of course, will not become complete until all the high-voltage oil circuit breakers and disconnecting



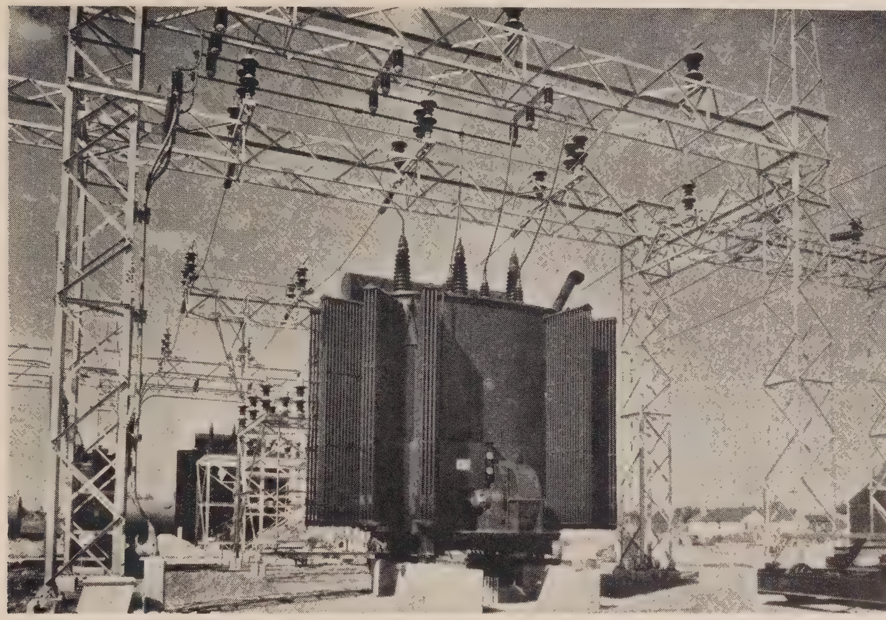
General view of station, control building at the left.

switches are installed. Each of the power transformers can be isolated from the ring by opening an electrically controlled, gang-operated set of air-break switches. Increased operating flexibility is obtained by the introduction of two high-voltage bus-ties. All the disconnecting switches in the ring are of the 3 stack double-break type. With the exception of the transformer switches, all disconnects on the 110 kv. installation are manually controlled, gang-operated. The 110 kv. bus is made up partly of 350,000 cir. mils stranded copper and partly of 1½ inch i.p.s. copper tubing. The 26 kv. transformer buses are 1½ inch i.p.s. copper tubing.

The 110 kv. oil circuit breakers are rated at 800 amperes, 138 kv. with an interrupting capacity of 1,500,000 kv-a.

Three single conductor 1,250,000 cir. mils, p.i.l.c. cables, connect each transformer through underground duct to the 26 kv. switch structure. This structure is equipped with two 26 kv. buses, from each of which three outgoing feeders are normally supplied. To facilitate maintenance and repair work on any part of the 26 kv. equipment without interrupting the service, any outgoing feeder can be temporarily switched over to the other bus by closing a double-break, gang-operated, manually controlled disconnecting switch, thus feeding two outgoing lines through one oil circuit breaker and permitting the other to be taken out of service. Likewise, the station service transformer and the grounding transformer can be fed from either one of the two buses. As a further means of flexibility the equipment in the station service bay is designed to serve as a bus tie for the two buses in the structure. In the future, two bus-tie oil circuit breakers will permit cross-tying between the two structures.

Excepting the grounding transformer breakers, all the 26 kv. oil circuit breakers are interchangeable, all being rated at 34.5 kv., 800 amperes with 750,000 kv-a. interrupting capa-



One of the 25,000 kv-a., 3 phase, 110/26 kv. transformers.

city. The 26 kv. buses at the structure are 2 inch i.p.s. tubing, with 1½ inch i.p.s. tubing in transformer breaker and station service bays and 1¼ inch i.p.s. tubing in the feeder bays. The connections from the oil circuit breakers to the adjacent disconnecting switches are made up from 1,000,000 cir. mils flexible stranded copper. Provision has been made for installation of feeder reactors in each of the outgoing circuits if such should be required in the future. The grounding transformers, installed to establish a neutral ground on the otherwise ungrounded 26 kv. circuits and to limiting the currents during a line-to-ground fault, are rated 26.4 kv., 3 phase, 25 cycles, 60 ampere continuous. A departure from the usual type of equipment on structures of this type and voltage is the introduction of station post type insulators.

The station service transformers one of which will be installed at each structure, are rated at 200 kv-a., 26,400-13,200/115-199-230 volt, 25 cycle, 3 phase, 4 wire. One of these is capable of supplying the necessary light and power for the station, the other serving as a stand-by. The secondaries are connected through 600 ampere fuses at the transformers, and four 1,000,000 cir. mils r.i.l.c. underground cables to the outer terminals of a 3 p.d.t. switch located in the station service distribution cabinet in the control building basement.

All control circuits, and the circuits for lighting, heating and power, are carried in r.i.l.c. cables in 2 inch fibre ducts from the basement under the control room, through a system of concrete handholes and manholes,

Low voltage structure.

thence in galvanized iron conduits to destination in the yard. These fibre ducts and conduits are all encased in concrete and drain into the handholes, which in turn are drained into the sewers. When the station reaches its final stage, a total of some 32,000 feet of 2 inch fibre conduit and some 10,000 feet of galvanized iron conduits of various sizes will have been installed. In addition, there will be some 3,000 feet of 4 inch fibre conduit for the 26 kv. cables.

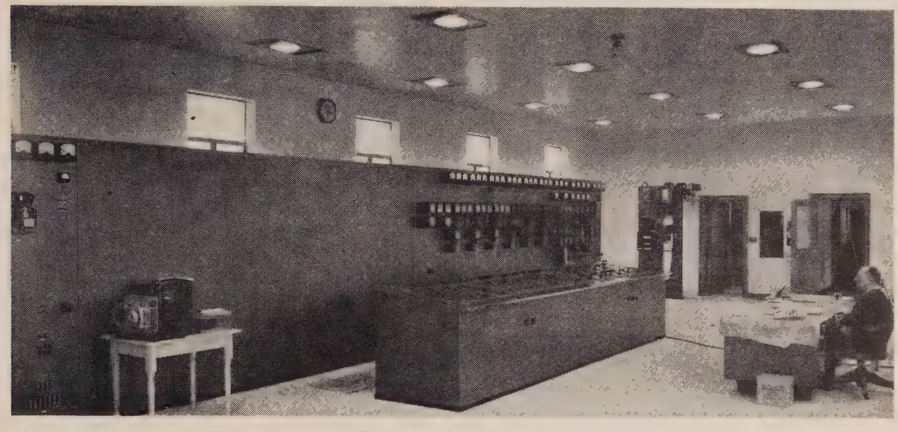
The single storey control building with a full basement covers an area of 84 by 33 feet. It contains, on the main floor, besides the control room, an office, lunch room, locker and wash rooms.

The control switchboard, which is of the bench type, and the relay board as well as the annunciator panel, are fabricated from stretcher levelled steel. The totalizing and battery panels are of the standard ebony asbestos. All boards and panels are finished in bronze, instead of the usual black.

Twenty-three recessed lighting fixtures fitted with 200 watt lamps are built into the suspended ceiling in the control room. These units provide a well distributed illumination of 30 foot candles, practically shadow free. In addition, an emergency light with automatic throw-over switch to the battery circuit has been installed in the control room.

The station service distribution centre is housed in a large steel cabinet in the basement. This cabinet contains, besides the double throw switch to which the mains from the station service transformers are connected, a number of switch-units varying in sizes from 600 amperes down to 35 amperes, and controlling the several a.c. distribution subcentres located in the yard and in the control building.

A motor-driven fan, forcing air from the basement at the rate of



Control room.

5,500 cubic feet per minute through a filter and heating chamber and a system of ducts to warm air outlets in the main floor below the windows provide the necessary heating. At the present, a completely thermostatically controlled group of electric heaters are installed in the heating chamber. Air returns from the control room through two floor grilles to the basement, thus completing the circulation. It is the intention to replace the electric heaters with a steam coil on the completion of the station. This system provides for about seven changes of air per hour, and may be used in the summer for air circulation.

Adequate control room ventilation has been provided through two roof monitors, each equipped with a three speed fan. The air is drawn through the grille mountings for the lighting fixtures in the ceiling.

The usual outside lighting for general illumination of the structure has been supplemented by six floodlight units installed at the four corners of the property.

Since the 110 kv. lines supplying this station are relatively short, they have been equipped with pilot wire relay protection. The 110 kv. and 26 kv. buses are provided with high speed current differential protection with the former one supplemented by an over current supervising feature on the 110 kv. lines. The main transformers have high speed current, gas detector and timed current relaying. The 26 kv. feeders are radial and are equipped with high speed and standby feature for protection against short circuits and single high speed current relay for "grounds".

Two oil storage tanks, each with a capacity of 10,000 imperial gallons have been provided. Underground pipe lines lead from these tanks to oil pumps and a filtering plant temporarily located near the place where a future maintenance building will be erected. From this pump house, oil is piped to and from all the transformers and oil circuit breakers.

Power Development of the Madawaska River

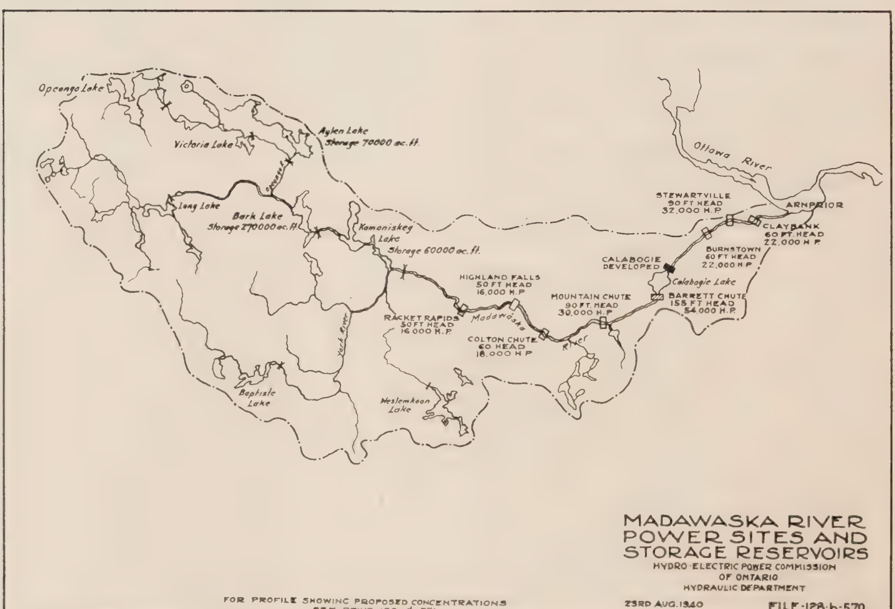
THE growth of the primary load on the Eastern Ontario system of The Hydro-Electric Power Commission during the last twelve months and the number of new loads which are now definitely in prospect will more than use up the generating resources and the purchased power of that system, which amount to 148,000 h.p.

Fortunately this will not mean that there will be any curtailment of the power supply to the primary power consumers. The deficiency will be made up by the Niagara system through a frequency-changer at the Chats Falls plant on the Ottawa river.

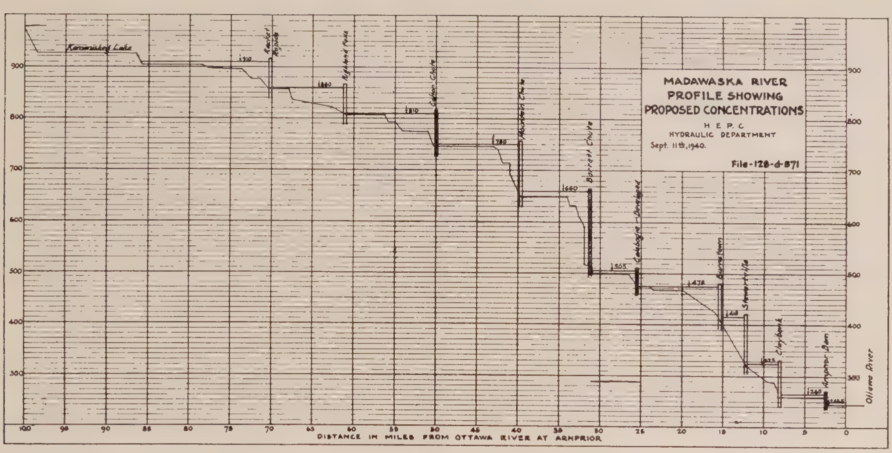
Present estimates indicate that some 17,000 h.p. will be transferred in December, 1940, and 47,000 h.p. in the fall of 1941. The maximum dependable capacity of the frequency-changer is 48,000 h.p.

In the fall of the following year the deficiency will exceed the capacity of the frequency-changer by some 8,000 h.p. and additional 60-cycle generating facilities will have to be provided.

In order to meet this situation, The Hydro-Electric Power Commission proposes to proceed immediately with the construction of a 54,000 h.p. development at Barrett chute on the Madawaska river. This is the first of eight important power sites on this river proposed to be developed ultimately by the Commission. When all eight are developed and the requisite



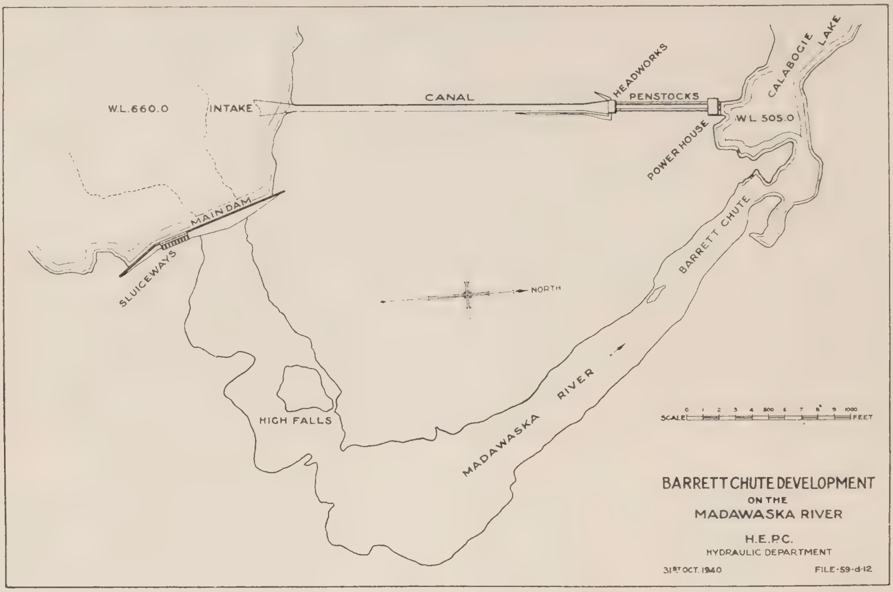
MADAWASKA RIVER POWER SITES AND STORAGE RESERVOIRS
HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO
HYDRAULIC DEPARTMENT



storage basins to regulate the flow of the river are completed, some 200,000 additional horsepower will be made available for use in the eastern part of the province.

The Madawaska river, rising in Algonquin Park, flows south-easterly to enter the Ottawa river at Arnprior. Having a drainage area of 3,300 square miles, it is the largest tributary of the Ottawa in Ontario. In the upper reaches particularly, and on certain of its tributaries, there are lake expanses of a considerable size, many of which are capable of development as storage basins of large capacity, which will enable the flow of the river to be regulated satisfactorily for the development of the large amount of power indicated above. From Bark lake, where the first of these storage basins will be located, the river falls 750 feet to reach the Ottawa river, and it is in this part of the river that the power developments will be made, varying in size from 16,000 h.p. at Racket rapids, under a head of 50 feet, to 54,000 h.p. at Barrett chute, where a head of 154 feet will be made available. The location and the size of the developments are shown on the map of the drainage basin, and the heads are indicated in the profile of the river. The Commission already has one development on the river at Calabogie at the foot of Calabogie lake, purchased along with numerous other assets of the O'Brien interests eleven years ago, and incorporated later in the Commission's Eastern Ontario system.

As indicated, the first development on the river, aside from the one already operating, will make use of a fall of 154 feet in the five miles of the river immediately above Calabogie lake. The power-house site is close to the lowest rapid in this part of the river, and the development bears the name of this rapid, Barrett chute. A plan shown herewith indicates the general scheme of development. A concrete dam, 100 feet in height from foundation to crest and about 1,150 feet long, will be built across the river above High falls. From the headpond formed by the dam, a canal, excavated in rock, will lead to head-



Plan of proposed development at Barrett Chute.

works 2,000 feet distant from the intake. Thence two steel penstocks, about 14 feet in diameter and 600 feet long, lead to the power house, which is to be located close to the shore of Calabogie lake, and a short tailrace will convey the water discharged from the turbines to the lake. The power house will contain two generating units, consisting of turbines having a rated capacity of 28,000 h.p. each, and generators rated at 24,000 kv-a. Power will enter the transmission lines of the Eastern Ontario system through a transformer and switching station, where the generator voltage of 13,200 will be stepped up to 110,000 volts.

At the same time as the development is being built, a storage dam will be constructed at the outlet of Bark lake to provide storage amounting to 215,000 acre-feet of water, that is to say, sufficient water to cover 215,000 acres to a depth of one foot. Structures are so designed that this may be increased later to 270,000 acre-feet. The construction of the Bark lake storage reservoir is itself a major job. The storage dam is a concrete structure, 400 feet long, having a maximum height of 65 feet, crossing the main channel at the lake outlet, with an earth dam extending a distance of 700 feet from the end of the concrete dam to high ground on the right. There are involved also the improvement of about ten miles of highway to give access to the site, the relocation of fifteen miles of Provincial highway, and various other minor matters.

When the Commission obtained control of the power rights on the river, it was anticipated that 140,000 h.p. might be developed there. Because

the developments will form part of an extensive system including many other developments on the Trent, Mississippi and Madawaska rivers, and are connected to the Commission's Niagara system, it is possible to take advantage of the seasonal variation in load in the southern part of the province to increase the ultimate capacity of developments on the river. The Niagara system has large supplies of surplus energy available during the summer months, by virtue of the lesser demands at that season than in the late fall and winter months. It is possible, therefore, for many months in the year to transfer energy from the Niagara system to the Eastern system, and it is proposed so to make this transfer as to conserve water stored in the reservoirs of the Madawaska river, reserving the stored water to generate energy during the winter months when the demands are greatest. Careful studies of the problem indicate that, by operating the Madawaska river developments to take advantage of seasonal surpluses of power elsewhere, it is possible to increase the capacity of the developments on the river considerably above what was anticipated at the time the development rights were acquired. The total capacity of the eight sites is now estimated to be 200,000 h.p.

Sir Oliver Lodge

AMONG the giants of science who achieved fame in later Victorian times none stands out with greater general prominence than Sir Oliver Lodge, whose death, at the age of 89 years, occurred on August 22. Unlike many of his contemporaries his name was almost as familiar to the general public as within the narrower limits of scientific bodies. Moreover he was, physically, a most impressive figure, of pleasant and approachable personality. Born in 1851 at Penkhull, near Stoke-on-Trent, Oliver Joseph Lodge at the age of 14 went to work in his father's business in the Potteries. Science was his star, however, and his early struggles to attain it show fine determination to rise above difficulties of finance. Evening classes, lectures on heat by Prof. Tyndall, a winter's course at South Kensington Chemical Laboratory, lectures and laboratory work under Prof. Huxley, and Matriculation in 1871 were the groundwork of his later scientific career. He taught in exercise classes at University College, London, by the good offices of Prof. Carey Foster, enabling him to live without calling too much on home aid. For five years he studied mathematics under Professors Clifford and Henrici in London. In 1875 he took his B.Sc. degree, and about the same time became demonstrator of physics at London University, and he published in conjunc-

tion with Prof. Foster, papers on the "Flow of Electricity in a Plane conductor." In 1876 at Heidelberg, he read and analysed the first volume of Maxwell's "Electricity," and exhibited before the British Association a model to illustrate the passage of electricity through metals and other material, according to Maxwell's theory. From thence onwards came papers and suggestions on many electrical subjects, measurement of battery resistance, the standard Daniell cell, etc. He became a doctor of science in 1877; in 1887 assistant Professor of Physics at University College, and treatises and textbooks on electrical and mechanical subjects came from his pen. During the year 1886-7 his research work was mostly devoted to electrolysis, and he was secretary of the Electrolysis Committee. Then came work on Leyden jar discharges and on waves in conductors. There followed proof that electrical wavelengths could be measured, and we find him in the years that followed dealing with lightning discharge, the ether theory, the propagation of light and electricity. He worked in the Cavendish Laboratory, Cambridge, in conjunction with Dr. Glazebrook. In 1888 St. Andrew's University conferred on him the honorary degree of LL.D., and shortly afterwards he was admitted a Fellow of the Royal Society. He was connected with the British Association for many years, and was President of Section A in 1891. Lectures at the Royal Institution were on deposition of dust and fume by electricity, on fuel and smoke, and so on, and many will remember his published consideration of fog dispersal. Lightning conductors and guards were another subject to which he contributed valuable data and theory. Hertzian waves and, following them, wireless telegraphy naturally attracted him; he demonstrated a method of signalling through space by Hertzian waves in 1894. He was appointed principal of the new University of Birmingham in 1900, and he was knighted in 1902 on the occasion of King Edward VII's coronation. Electrons, the properties of matter and germane subjects occupied much of his time in the first decade of the 20th century; but other things also in his researches about this period were electrification of crops, high-tension rectifying valves and ignition devices for internal combustion engines. He was President of the Physical Society from 1899 to 1904, and President of the British Association in 1913. In 1932 he was awarded the Faraday medal by the Institution of Electrical Engineers.

In his latter years, since his retirement in 1919, he swung over to the psychological side of science, and the world is promised, if his theories are correct, some manifestation from the other side at a fairly early date.—*The Electrical Times.*

Ogoki River Diversion

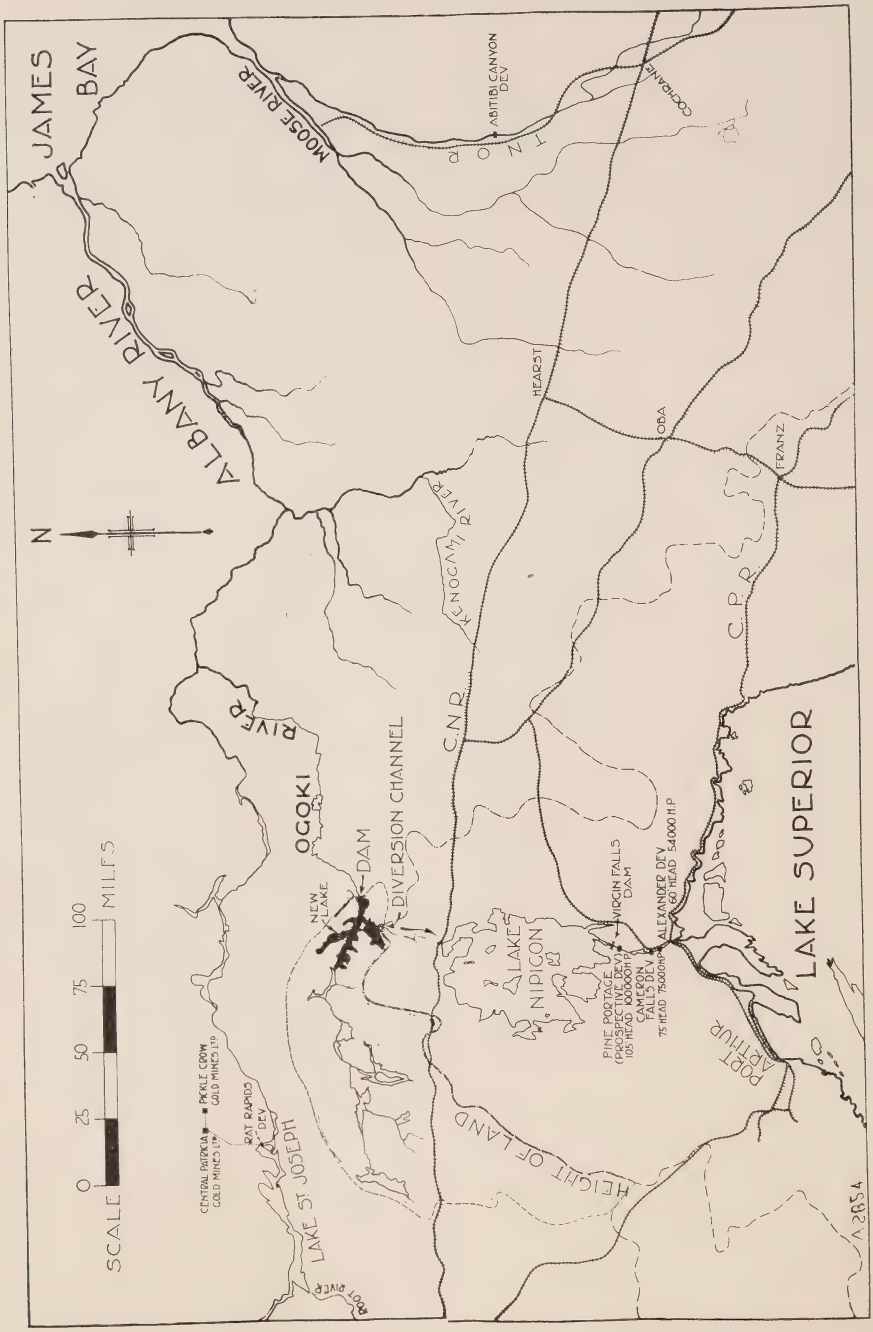
THE Albany river is one of the largest rivers in Ontario, being exceeded in size only by the St. Lawrence and the Ottawa. It drains an area of some 50,000 square miles and empties into James bay from the west, after falling a distance of 1,220 feet from lake St. Joseph in a distance of 470 miles. Its two principal tributaries are the Ogoki and the Kenogami. The Albany river played an important part in the early history of western Canada, having served as a transportation route between tide-water on James bay and the interior to the west. The main route to the Red River Settlement, where the city of Winnipeg now stands, was from Fort Albany up the Albany river to lake St. Joseph, across the height of land into the Root river and Lac Seul, and thence down the English and Winnipeg rivers to lake Winnipeg. A subsidiary route to lake Superior was up the Ogoki river, across the height of land, down the Ombabika river to lake Nipigon and thence down the Nipigon river to lake Superior. These routes were also used to a very considerable extent by the Hudson Bay Company and by the fur traders of the district.

Description of Project

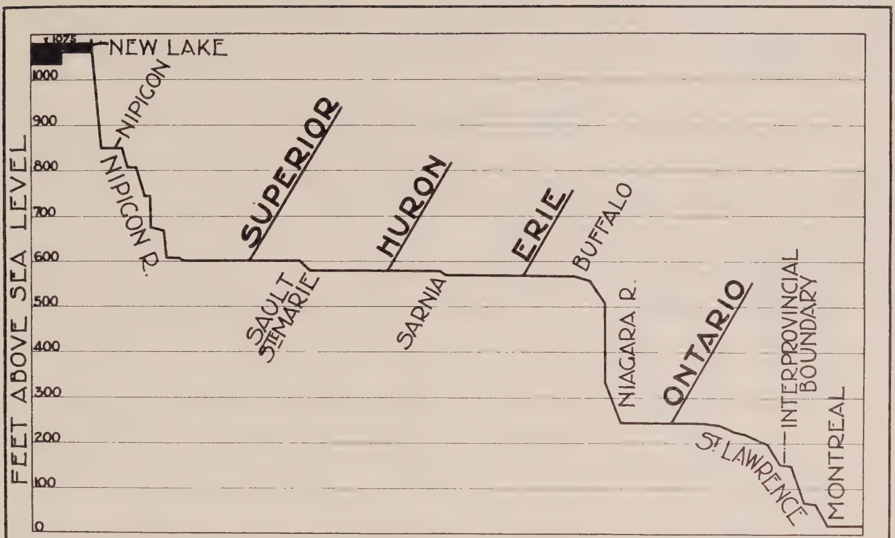
The possibility of diverting some of the water, which now empties into James bay, into the Great Lakes system, was first realized in January of 1924 when a reconnaissance was made, by one of the Commission's engineers, of the height of land between the Ogoki river and the headwaters of the Jackfish river, and of the divide between the Ogoki and the Albany rivers. The information secured from this reconnaissance justified a more detailed study of the proposal, and the ensuing two years were spent in a careful topographical survey of the district. As a result of this survey, it was determined that a dam could be built on the Ogoki river at Waboose rapids to divert the run-off above this point across the height of land and into the chain of lakes feeding the Jackfish river. Thence the water would pass down Seymour creek into lake Nipigon and down the Nipigon river to lake Superior. The diversion of the Ogoki river was found to be entirely feasible.

The drainage area above the proposed Ogoki river dam is 5,800 square miles, and the mean run-off, based on the known rate of run-off of adjacent rivers, is approximately 4,000 c.f.s. This flow, if diverted at a variable rate, could be stored in lake Nipigon and be let out at a uniform rate, or as required, by means of the Virgin Falls regulating dam at the outlet of lake Nipigon. A map of the district shows the geographical location of the various works involved in the diversion project.

The works required in connection with the diversion of this Ogoki river flow would consist of a main dam at the head of Waboose rapids having a maximum height of fifty feet and a crest length of 1,700 feet. Two auxiliary dams adjacent to the main dam



Map showing location of diversion project.



PROFILE FROM OGOKI RIVER TO MONTREAL

are also required to close weaknesses in the high contour. A third auxiliary dam will be required on Snake creek which flows into Mojikit lake from the west. These dams will flood upstream to the west a distance of thirty miles, and to the south into Mojikit lake. The total area of this new lake which would be created will be 120 square miles, of which 80 square miles will be flooded area. The raised water level will extend southerly from Mojikit into a small lake known as North Summit lake, and channel improvements at the summit, containing control works, will be required to pass the diverted water into South Summit lake. From South Summit lake the water will flow through a series of small lakes into Seymour creek, and thence into lake Nipigon. Improvements are required in some of the connecting channels in the lakes at the head of Seymour creek, and a new underpass required at the crossing of the Canadian National Railway immediately north of lake Nipigon.

Benefits to Navigation

It will be evident that the supply of additional water to the Great Lakes system will result in a raising of the levels of all of the Great Lakes and interconnecting channels and of the St. Lawrence river. This will not be of particular benefit on lake Superior, the level of which is now regulated by control works at Sault Ste. Marie, or on lake Ontario where the question of navigable depths is not of prime importance.

An addition of 4,000 c.f.s. to the Great Lakes system would result in an increase of 2.1 inches in the level of lakes Huron, Michigan and Erie at mean stage. It has been estimated that a dependable addition of 1 inch in depth of these three lakes is worth $500,000 a year to the shipping in-

terests, and at this rate 2.1 inches would represent a saving of approximately $1,050,000 a year. The major benefit of such an increased level would be to the iron ore and coal transport companies of the United States. Canadian shipping would also benefit to some extent but to a very much lesser degree. This diversion would also result in an increase of 1.4 inches in level in Montreal harbour at low stage.

It may be possible to drive pulpwood from the Ogoki river to lake Nipigon for use in mills to be constructed in that vicinity or on down the Nipigon river to the mills in the vicinity of Port Arthur. However, this may not be found to be economical for some time to come.

Power Available

There is a total fall from the Ogoki divide to Montreal harbour of approximately 1,040 feet. The same fall of course exists under present conditions from Waboose rapids down the Ogoki and Albany rivers to James bay. While the diversion of the Ogoki river into the Great Lakes system would not result in any increase of total potential power, it would bring the water so diverted much closer to existing markets.

Of this total head of 1,040 feet, it is estimated that about 980 feet would be capable of economical development. About 580 feet is partially or wholly developed at present.

On the Nipigon river 135 feet is at present developed in the Commission's two plants at Cameron Falls and Alexander, and the additional diversion could be utilized through these two plants to produce considerable additional energy. Power plants are available at Sault Ste. Marie to utilize the Ogoki water there. The additional flow could be utilized through the Commission's Toronto Power plant at Niagara Falls to produce additional energy or through a new development to be constructed at Niagara Falls. The international section of the St. Lawrence is undeveloped at the present time. The 4,000 c.f.s. would add approximately 104,000 continuous horsepower to the Commission's plants on the Nipigon and Niagara rivers, and 8,000 horsepower to the plant at Sault Ste. Marie, 230,000 horsepower in Ontario being at present undeveloped.

Fatigue Tests on Zinc-Coated Steel Wire

By D. G. Watt, Assisting Testing Engineer, H.E.P.C. of Ontario

THE progessive failure of overhead conductor cables due to aeolian virbrations presents a serious problem to engineers responsible for the design and maintenance of power-transmission lines. A great amount of study has been devoted to the cause and nature of conductor vibration and to the devising of mechanical dampers to suppress it below a harmless limit.

Coincident with the advances which have been made in restricting the intensity of cable vibration to the point where indefinitely long or at least extended conductor life will result, efforts have been made to obtain conductor materials with the best fatigue properties and to ensure that these properties are maintained during manufacture by checking from time to time the endurance limit of the wire from which the conductor is being fabricated.

The simple reversed bending fatigue test, while it does not duplicate the complex stress conditions to which the wires in a vibrating cable are subjected in the field, furnishes the most practical method of measuring the relative ability of materials to withstand vibration failure. For application of wire in overhead conductors, where aeolian vibrations may occur, the results of fatigue tests on the material have more significance than much of the data obtained from the standard or commonly prescribed wire-quality tests. Measurements of tensile strength, elastic limit, and ductility still constitute the basic requirements of the majority of wire specifications. In spite of the fact that such data are essential to the designer and in many instances are related to service life, it is common knowledge that the results fail to reveal whether the material has the required fatigue strength for applications in which vibratory stressing may occur.

The work recorded in this paper represents a part of The Hydro-Electric Power Commission's researches on the fatigue properties of conductor materials, namely, that dealing with zinc-coated steel wire of the type from which transmission line ground wire cables are stranded.[1]

Briefly, the objects of the investigation were as follows:

1. To compare the endurance limits of zinc-coated steel wires of the following grades:

220,000 to 250,000 p.s.i.
170,000 to 190,000 p.s.i.
110,000 to 120,000 p.s.i.

2. To determine the extent to which the hot-dip galvanizing process affects

Presented to the American Society for Testing Materials at Atlantic City, June 27, 1940.

[1]Ground wire cables are seven-strand galvanized steel cables strung between transmission line towers for protection against lightning.

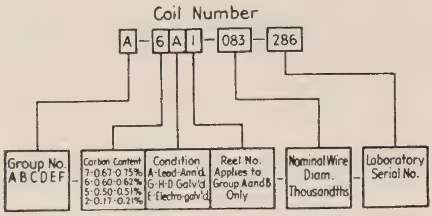


Fig. 1.—Key to coil numbering system.

the endurance limit of steel wire in the lead-annealed condition.

3. To determine, within a specified range, the influence of the thickness of zinc coating on the endurance limit.

4. To determine whether the results of the ordinary quality tests, as carried out at the mill, namely, tensile strength, percentage elongation, bends and twists to failure, give any indication of the fatigue properties of the wire.

5. To supplement physical tests by microscopic examinations of the wires and their coatings to determine, where possible, the factors which are deleterious to the fatigue properties of the material.

MATERIALS

The investigation was carried out on wires classified on the basis of tensile strength in Table I. The tabulated data include the condition in which the wire was tested, the chemical composition, diameter, and weight of zinc coating. The key to the sample numbering system is explained in Fig. 1.

All coils of 170,000 to 190,000 p.s.i. grade wire in group B were drawn from the same melt of steel. Samples were obtained from four reels of wire diameters 0.080, 0.101, and 0.117 in. Part of each reel was withdrawn from the continuous process after lead-bath annealing. The remainder was subjected to the complete coating process, including lead-bath annealing, pickling, and hot-dip galvanizing.

The 220,000 to 250,000 p.s.i. grade wires in group A were drawn from two melts of steel, the one of lower carbon content being used for the 0.082-in. diameter wire. The sample coils were obtained from two reels of each diameter. As in the case of the wires in group B, a portion of each reel was lead-annealed and the remainder hot-dip galvanized.

All of the wires in group D and some of the wires in groups E, F, and G were zinc coated by electrolytic processes.

TEST METHODS

The fatigue data presented in this paper were obtained from tests carried out on two Haigh-Robertson wire fatigue testing machines, one of which is shown in Fig. 2. Since these testing machines, or slight modifications, are in general use and have been described in detail elsewhere, it is only necessary to outline briefly the principle of operation here.[2]

In Fig. 2 it will be observed that one end of the wire specimen under test is gripped in the chuck on the motor shaft. The other, fitted with a small cup-faced sleeve, runs on a ball thrust bearing mounted in a movable tailstock on the bed of the machine. The headstock, including the driving motor and chuck, is free to turn on a vertical axis coincident with the chuck jaws. By means of a fine

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[2] "Fatigue Testing Machine for Wire," *Engineering*, Vol. 138, August 10, 1934, p. 139.

"Haigh-Robertson Fatigue Wire Testing Machine," The Bulletin, Vol. XXIII, No. 6, June, 1936, p. 192.

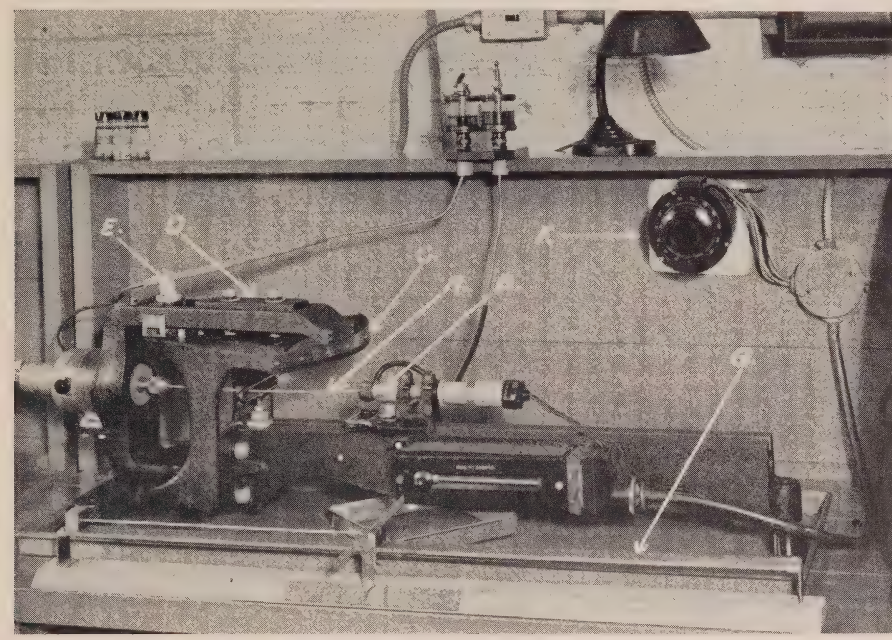

Fig. 2.—Haigh-Robertson fatigue testing machine. A—Wire specimen. B—Tailstock. C—Angular scale. D—Headstock. E—Vertical headstock bearing. F—Speed control. G—Specimen length gage.

screw adjustment, the thrust bearing on the tailstock may be moved towards the headstock and the wire specimen thus given any desired degree of deflection as a strut and simultaneously rotated by the motor about the neutral axis.

If the modulus of elasticity of the wire is known, the maximum stress in the specimen, which occurs at mid-length, may be calculated from its length-diameter ratio and the angle of inclination at the free ends. This angle is read directly from the vernier angular scale attached to the swinging headstock. In the case of the zinc-coated wires the length-diameter ratio was based on the diameter of the steel. The principle of load measurement employed in the Haigh-Robertson machine assumes that the wire specimen was originally straight. If this requirement is not fulfilled and the wire contains any small kinks, twists of long radius bends, secondary vibrations will be set up in the rotating specimen and it will not conform to the smooth curve on which the stress calculations are based.

The wire samples, as received, contained the natural curvature of the coil produced by winding on the take-ups in the galvanizing plant. Straightening of the specimens was first carried out by pulling each in a testing machine to the so-called yield point determined by the drop of the beam. This method, which was originally

TABLE I—SUMMARY OF TEST DATA

Grade	Coil Number	Wire Diameter, in. (Steel)	Composition, per cent				Condition	Weight of Zinc Coating, oz. per sq. ft.	Tensile Strength, p.s.i.	Elongation in 10 in., per cent	Twists to Failure, Length = 100 D		Bends to Failure, 180 deg., r=0.187 in.		Modulus of Elasticity, p.s.i.	Endurance Limit, p.s.i.	Endurance Ratio per cent
			Carbon	Manganese	Phosphorus	Sulphur					Number	Average Variation, per cent	Number	Average Variation, per cent			
220,000 to 250,000 p.s.i.	A-6A1-083-286	0.082	0.60	0.98	0.028	0.028	Lead-annealed	....	232 500	5.1	26.4	3.0	17.0	0.0	28 800 000	73 200	31.4
	A-6A2-083-272	0.082							229 000	5.0	30.5	1.5	17.0	0.0	29 200 000	73 000	31.8
	A-7A1-104-276	0.103	0.75	1.10	0.029	0.030	Lead-annealed	....	258 200	5.1	24.1	1.0	10.8	2.8	29 000 000	71 500	27.6
	A-7A2-104-280	0.103							255 800	5.0	27.4	1.0	8.8	3.4	28 700 000	73 800	28.9
	A-7A1-125-282	0.123							227 000	5.4	27.4	1.0	11.6	3.4	27 800 000	65 000	28.6
	A-7A2-125-284	0.123							225 800	5.3	27.2	1.0	8.8	4.2	28 000 000	67 200	29.8
	A-6G1-083-287	0.082	0.60	0.98	0.028	0.028	Hot-dip galvanized	0.087	227 000	5.3	26.5	2.0	13.4	3.7	28 700 000	58 200	25.6
	A-6G2-083-273	0.082						0.088	226 500	5.2	23.8	3.0	11.8	2.5	28 700 000	58 500	25.8
	A-7G1-104-277	0.103	0.75	1.10	0.029	0.030	Hot-dip galvanized	0.95	248 000	5.6	23.1	3.0	11.0	0.0	28 900 000	60 500	24.4
	A-7G2-104-281	0.103						0.92	248 000	5.7	23.1	1.0	9.0	0.0	28 800 000	60 500	24.4
	A-7G1-125-283	0.123						1.05	223 000	5.5	27.6	3.0	7.0	0.0	29 200 000	54 200	24.3
	A-7G2-125-285	0.123						1.01	224 000	5.5	28.2	1.0	9.0	0.0	28 400 000	54 100	24.2
	C-7E-083-200	0.080	0.73	0.67	....	....	Electro-galvanized	0.92	255 800	5.2	26.2	15.0	16.0	0.0	28 900 000	72 700	28.4
	C-7E-104-201	0.101	0.74	0.63	....	....	Electro-galvanized	0.94	240 100	5.4	26.2	13.0	11.0	0.0	28 500 000	66 400	27.6
	C-7G-104-202	0.101	0.74	0.71	....	....	Hot-dip galvanized	1.08	230 100	5.2	12.8	43.0	9.3	4.3	29 100 000	57 100	24.7
	C-7E-125-203	0.122	0.67	0.72	....	....	Electro-galvanized	0.90	234 900	5.3	17.0	27.0	7.0	0.0	28 500 000	58 600	24.9
170,000 to 190,000 p.s.i.	B-5A1-083-236	0.080	0.50	1.06	0.025	0.023	Lead-annealed	....	181 000	6.4	37.9	1.7	17.0	0.0	29 500 000	69 500	38.4
	B-5A2-083-241	0.080							183 000	6.9	35.3	3.4	17.4	2.9	29 400 000	73 000	39.9
	B-5A3-083-246	0.080							187 700	6.0	36.0	0.0	19.0	0.0	29 600 000	69 000	36.8
	B-5A4-083-251	0.080							186 200	6.0	34.9	2.3	19.2	1.6	29 500 000	74 100	39.8
	B-5A1-104-200	0.101							170 200	6.9	33.4	4.1	13.1	0.0	29 600 000	67 200	39.4

	B-5A2-104-224	0.101							175 800	6.9	31.5	3.5	13.4	3.7	29 200 000	65 700	37.4
	B-5A3-104-228	0.101							178 800	7.0	35.0	6.3	14.0	0.0	29 000 000	64 500	36.1
	B-5A4-104-232	0.101							172 800	7.3	33.4	6.9	11.8	2.5	29 000 000	66 000	38.2
	B-5A1-125-204	0.117	0.50	1.06	0.025	0.023	Lead-annealed	....	171 200	6.6	30.0	1.3	11.0	0.0	28 500 000	61 400	35.8
	B-5A2-125-208	0.117							176 100	6.4	30.4	1.6	11.8	2.5	28 700 000	61 100	34.6
	B-5A3-125-212	0.117							177 100	6.4	31.0	0.0	9.0	0.0	28 200 000	62 600	35.3
	B-5A4-125-216	0.117							178 000	6.6	33.0	0.0	11.0	0.0	28 700 000	65 100	36.6
	B-5G1-083-238	0.080						0.88	179 200	6.1	23.8	3.2	11.2	2.7	29 800 000	50 800	28.4
	B-5G2-083-243	0.080						0.89	181 200	6.0	23.5	2.2	15.0	0.0	29 500 000	52 500	29.0
	B-5G3-083-248	0.080						0.85	182 000	6.0	23.2	1.4	12.2	2.4	29 600 000	52 600	28.9
	B-5G4-083-253	0.080						0.90	182 800	6.1	22.9	2.8	15.0	0.0	29 200 000	53 000	29.0
	B-5G1-104-222	0.101						0.93	170 400	6.5	22.0	0.0	11.0	0.0	29 300 000	50 900	29.8
	B-5G2-104-226	0.101	0.50	1.06	0.025	0.023	Hot-dip galvanized	1.15	168 000	6.6	21.6	2.2	11.2	2.7	29 200 000	47 500	28.3
	B-5G3-104-230	0.101						0.91	175 400	7.3	22.4	2.1	13.0	0.0	29 200 000	51 000	29.0
	B-5G4-104-234	0.101						0.94	170 000	7.1	22.4	2.2	11.0	0.0	29 000 000	48 500	28.6
	B-5G1-125-206	0.117						0.96	176 100	6.3	29.2	1.1	11.0	0.0	28 300 000	48 500	27.5
	B-5G2-125-210	0.117						0.81	178 000	6.5	29.2	1.1	11.0	0.0	28 600 000	48 300	27.1
	B-5G3-125-214	0.117						0.98	176 000	6.2	30.2	3.2	9.0	0.0	28 200 000	46 000	26.1
	B-5G4-125-218	0.117						0.90	178 100	6.0	27.2	1.2	9.0	0.0	28 300 000	48 000	26.9
	D-5E-104-259	0.100						0.90	189 800	7.2	29.5	1.7	11.0	0.0	28 700 000	56 200	29.6
	D-5E-104-260	0.098	0.51	1.07	0.014	0.024	Electro-galvanized	2.03	191 400	7.3	29.6	1.6	10.8	2.7	29 600 000	60 500	31.6
	D-5E-104-261	0.095						2.30	189 700	7.4	27.6	2.4	9.0	0.0	29 000 000	58 500	30.8
	E-6E-083-221	0.080	0.61	0.78	....	....	Electro-galvanized	1.05	189 500	6.3	30.6	9.0	8.3	7.2	28 500 000	65 000	34.3
	E-6E-104-223	0.101	0.62	0.87	....	....	Electro-galvanized	0.87	171 700	7.8	31.0	5.5	8.0	0.0	28 400 000	62 000	36.1
	E-6G-104-225	0.101	0.60	0.81	....	....	Hot-dip galvanized	1.10	175 000	7.2	17.0	7.5	7.8	3.9	28 500 000	54 800	31.3
	E-6E-125-227	0.122	0.61	0.92	....	....	Electro-galvanized	1.03	171 300	7.5	28.0	5.5	6.0	0.0	29 000 000	58 300	34.0
110,000 to 120,000 p.s.i.	F-2E-083-263	0.080	0.21	0.46	....	....	Electro-galvanized	0.95	118 000	6.4	34.7	9.8	18.0	6.6	28 400 000	50 600	42.9
	F-2E-104-264	0.101	0.19	0.42	....	....	Electro-galvanized	1.05	116 500	8.5	35.5	1.5	10.0	0.0	29 100 000	47 900	41.1
	F-2G-104-265	0.101	0.17	0.50	....	....	Hot-dip galvanized	1.01	112 800	8.2	19.8	3.0	8.9	2.2	28 600 000	43 100	38.2
	F-2E-125-266	0.122	0.20	0.49	....	....	Electro-galvanized	0.94	110 100	7.8	17.4	3.0	8.5	7.0	29 200 000	45 500	41.3

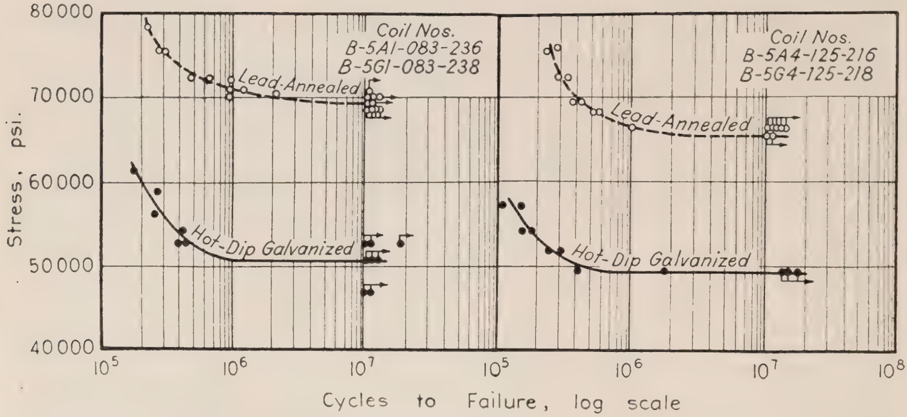

Fig. 3.—S-N curves on 170,000 to 190,000 p.s.i. grade lead-annealed and hot-dip galvanized wire.

suggested by the makers of the Haigh-Robertson machine, proved fairly satisfactory for 170,000 to 190,000 p.s.i. grade wire, although at times supplementary hand straightening was required.[3] In the case of the harder wires it was found that straight specimens could be obtained more conveniently by passing the wire through a small hand-operated straightening machine. Accordingly, after all of the tests had been completed on groups *A*, *B*, and *D*, the remaining tests were carried out on machine-straightened specimens.

The testing speed used was of the order of 6000 to 7000 rev. per min. In some of the tests higher and lower speeds were employed to eliminate specimen vibration.

Modulus of elasticity determinations were carried out on at least two wire specimens from each coil, strain measurements being recorded over a 10-in. gage length with an Anderson extensometer.[4] The samples for modulus of elasticity tests were straightened by the same methods as those employed for straightening the fatigue specimens.

Bend and twist tests were performed in the hand-operated machines, supplied by the W. & T. Avery Co.

TEST DATA

A summary of the test data obtained on each sample coil of wire is presented in Table I. The information includes values for tensile strength, percentage elongation, twists and bends to failure, modulus of elasticity, endurance limit, and endurance ratio, that is the ratio of endurance limit to tensile strength.

Typical *S-N* curves on wires of different diameters from groups *B* and *A*, in the lead-annealed and hot-dip galvanized conditions, are shown in Figs. 3 and 4. It will be observed that on some of the curves there was a range of stress, varying from 1000 to 3000 p.s.i. above the endurance limit, in which a number of the specimens

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[3] C. P. Wampler and N. J. Alleman, "Fatigue Tests of Wire," ASTM BULLETIN, No. 101, December, 1939, p. 13.

[4] H. A. Anderson, "Tension Tests of Thin Gage Metals and Light Alloys," *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 997 (1924).

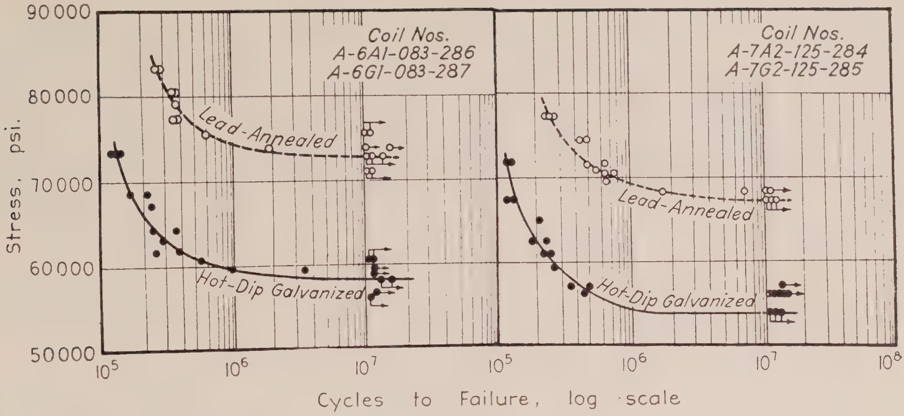


Fig. 4.—S-N curves on 220,000 to 250,000 p.s.i. grade lead-annealed and hot-dip galvanized wire.

broke at less than 10,000,000 cycles, while others, tested at the same stress, continued to run unbroken over the 10,000,000 cycle mark. It is thought that in this critical stress range, where the *S-N* curve is approaching the horizontal, a given degree of non-uniformity in the fatigue resistance of the specimens, such as that due to minute differences in surface condition, results in a greater variation in cycles to failure than at the higher stresses where the slope of the curve is steeper.

To facilitate ready comparison, the endurance limits of the wires are plotted in Fig. 5. Horizontal lines have been inserted to represent the average

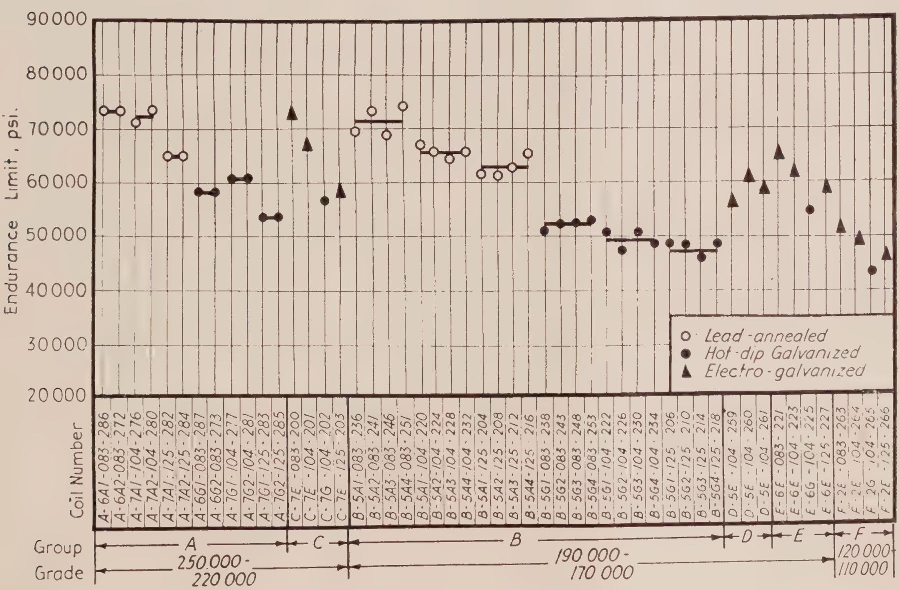


Fig. 5.—Endurance limits of all wires tested.

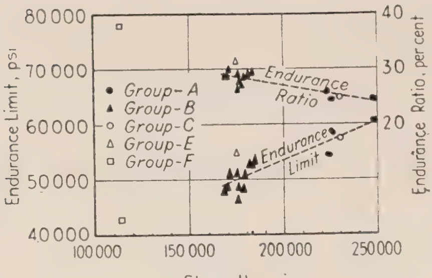


Fig. 6.—Plot of endurance limit and endurance ratio of hot-dip galvanized wires against tensile strength.

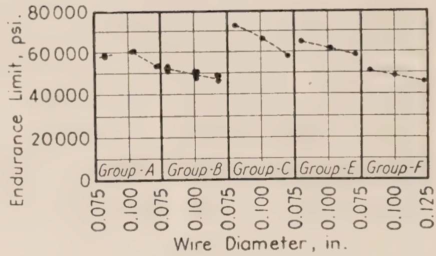


Fig. 7.—Endurance limits of zinc-coated wires from each group plotted against wire diameter.

of the test values obtained on sample coils of wire having the same diameter, similarly processed and made from the same melt of steel.

A comparison of the results obtained on the lead-annealed and hot-dip galvanized wires in groups *A* and *B* reveals the deleterious effect of the hot-dip galvanizing process on the endurance limits of the uncoated steel wires. Galvanizing depressed the endurance limits of the lead-annealed wires 11,000 to 20,000 p.s.i., the adverse effect of the coating being somewhat less for the wires in group A than for those in group B.

In Fig. 6 the endurance limits of all of the hot-dip galvanized wires are plotted against their respective tensile strengths. Although there is a considerable scatter in the points due to differences in chemical composition, reduction by drawing and processing treatments, the results indicate that the 220,000 to 250,000 p.s.i. grade wires have somewhat higher endurance limits than the 170,000 to 190,000 p.s.i. grade. The endurance limit of the one coil of 110,000 to 120,000 p.s.i. grade was lower than those of the two harder grades. The improvement in the fatigue properties of the wires as the tensile strength increased was accompanied by a loss in ductility as revealed by a smaller percentage elongation at failure in the tension test.

The plot of the endurance ratios of all of the hot-dip galvanized wires against their respective tensile strengths, in Fig. 6, shows that this ratio becomes smaller as the tensile strength of the wire is increased. Reference to the data obtained on the lead-annealed and the electro-galvanized wires in Table I reveals a similar relationship between the endurance ratio and the tensile strength for wire in these conditions.

The effect of drawing on the endurance limit of the zinc-coated wires is illustrated by Fig. 7, in which the endurance limits of the wires, from each sample group, are plotted against the wire diameter. It will be observed that in every case some improvement was effected in the endurance limit as the reduction by drawing was increased. The break in the curve for the samples from group A is due to the use of a lower carbon steel for the 0.082-in. diameter wire than for the two larger sizes. A similar effect

TABLE II

EFFECT OF COATING THICKNESS ON ENDURANCE LIMIT

Coil Number	Weight of Zinc Coating oz. per sq. ft.	Endurance Limit, p.s.i.		Endurance Ratio, per cent	
		4 Dip Coating	3½ Dip Coating	4 Dip Coating	3½ Dip Coating
B-5G1-083-238	0.88	50 800	......	28.4	....
B-5G1-083-239	0.68	......	52 500	.....	29.6
B-5G2-083-243	0.89	52 500	......	29.0	....
B-5G2-083-244	0.67	......	52 200	....	28.8
B-5G3-083-248	0.85	52 600	......	28.9	.....
B-5G3-083-249	0.69	......	53 300	....	28.6
B-5G4-083-253	0.90	53 000	......	29.0	....
B-5G4-083-254	0.70	......	52 500	....	28.7

may be noted between the endurance limits of the lead-annealed wires of various diameters.

It will be observed from the data in Table I that wires coated by electrolytic processes had endurance ratios slightly exceeding those obtained on the hot-dip galvanized wires of similar grade. Although variations in chemical composition, drawing, and heat treatment of the base wires may preclude a direct comparison of the relative effect of the two coatings, the results point to the superiority of the electro-deposited coatings over those applied by the hot-dip method, in so far as the fatigue resistance of the finished wires is concerned.

A number of tests were made to determine the effect of coating thickness on the endurance limit of hot-dip galvanized wire. Two coating thicknesses were employed, namely, those required to withstand four and three and one half dips, respectively, in the Preece test. The samples were obtained by applying the coatings to wire from corresponding reels. The results of the tests, presented in Table II, indicate that, within the range investigated, coating thickness had no perceptible effect on the endurance limit of the wire.

The average number of twists and bends to failure, along with the percentage average variation in the results obtained on the specimens from each coil, are shown in Table I. Plots of twists and bends to failure against the endurance limits of the wires revealed no definite correlation between these values.

(To be continued)

Prevention Easier Than Cure of Radio Interference

L. V. Blake, Radio Technician, Arkansas Power & Light Company, Pine Bluff, Ark.

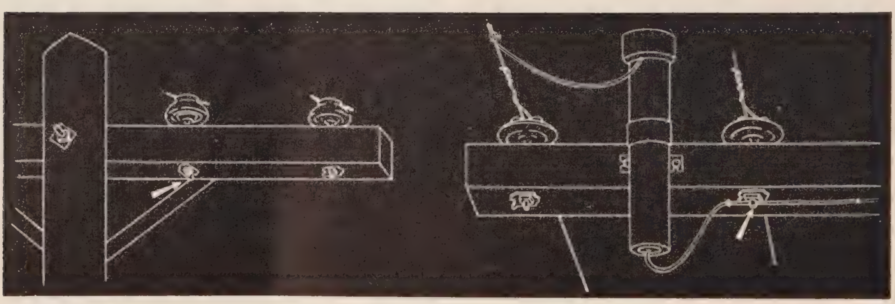
WE believe that any distribution engineer who swaps one ounce of radio interference prevention for a pound of cure has made a bad bargain. But, fortunately, he doesn't have to abide by his bargain, for there are some simple rules which, if followed consistently, will result in construction of distribution lines essentially free from avoidable sources of interference. Our bargain-minded engineer can start his prevention program with his next line extension.

All the construction rules which can be laid down are corollaries of one simple, general rule which will keep sources of radio interference at a minimum.

Connect all pole hardware solidly together, or keep it spaced well apart—The corollaries are these:

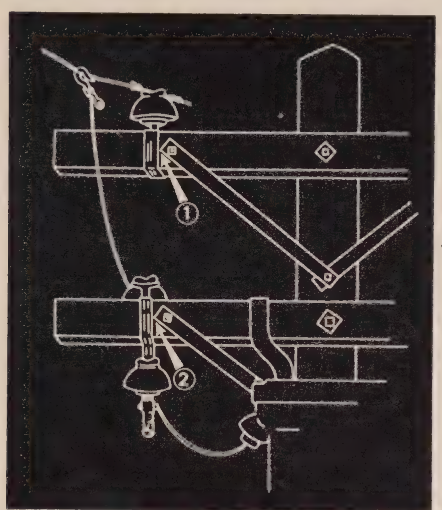
1. See that all hardware remains tight by periodic tightening.
2. Keep ground wires on poles clear of all ungrounded hardware.
3. Keep guy wires clear of all other wires and hardware.
4. Keep tie wires tight; on lines of above 5,000 volts avoid weatherproof insulation at ties and dead-ends.
5. In disk insulator assemblies use only standard type brass cotter pins.
6. Remove all pieces of "haywire" found hanging on line wires.

The explanation of radio interference caused by violation of these rules has not been given the attention it deserves. Briefly, it may be said that most important causes of radio interference are associated with the electrostatic field such as exists between any two conductors across which a voltage exists. Just as an



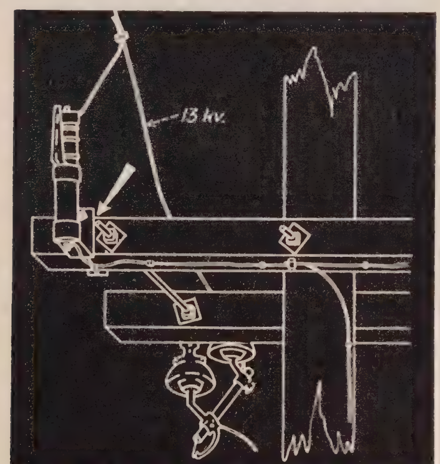
Washer on 13-kv. insulator pin too close to crossarm brace; keep all pole hardware spaced well apart.

Arrester ground wire close to 13-kv. insulator pin; ground wire should clear all ungrounded hardware (rule 2).



Insulator pin strap (or switch-mounting assembly) almost touching cross-arm brace; connect all pole hardware together or space it well apart.

electromagnetic field induces a voltage in conductors within its range,



Grounded lightning arrester mounting assembly too near spacer bolt washer (switch assembly on other end of bolt); keep grounded parts clear of all ungrounded hardware.

isolated conductors, such as line hardware, in an electrostatic field are subject to electrostatic induction. On an a.c. line a charge and discharge take place in such hardware exactly as in the plate of a condenser. Finally, if two units of hardware thus acted upon are *almost* touching, the intense field in the small gap may overstress and ionize the air at this point and allow the formation of a continuous arc. This explains the reason for the basic rule already given that: In constructing lines of 2,300 volts and above all pole hardware should be either solidly connected together or spaced well apart.

An inch or more spacing between units of hardware is sufficient, although it is well to instruct linemen to provide as much spacing as is consistent with good construction.

The accompanying sketches show a few typical conditions under which interference may, and often does, occur. Trouble of this nature is most frequently found on lines in the voltage region between 5,000 and 15,000 volts, although under "ideal" conditions the same trouble will occur in 2,300-volt lines. Lines of above 15,000 volts are generally used for transmission rather than distribution—there is less hardware on the poles and, accordingly, fewer chances for this kind of trouble.

It is occasionally difficult for some linemen to understand exactly what occurs under conditions similar to those shown in the sketches. As a result, some may tend to laxity in observing the rule. Seriousness of radio interference will be appreciated, however, from the fact that in many cases

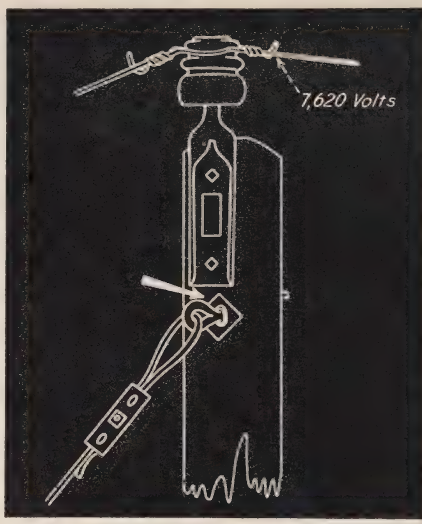
radio interference caused by an arc between two units of hardware on a 13-kv. line has been found to affect radio reception of customers along the line ten or more miles from the actual source of trouble. Frequently, customers within a mile or two of such a source of interference cannot receive any programs whatsoever.

Watch Out For—

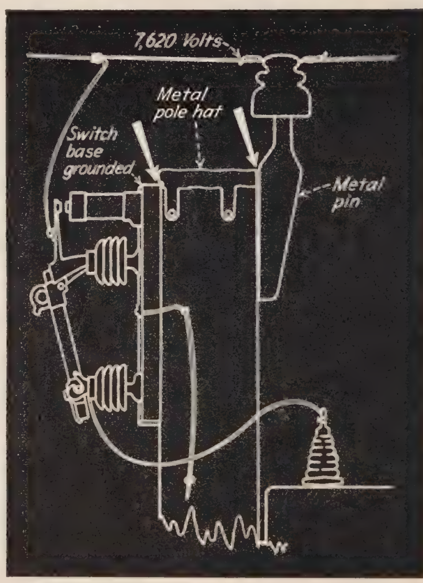
Discussion of the corollary rules laid down in the early part of the article may disclose some vulnerable points of construction which might otherwise be overlooked.

1. *Keep all hardware tight. Periodic retightenings are recommended*—Loose hardware is as frequent a source of radio interference as is hardware improperly spaced. If lag-screws, carriage bolts or through-bolts become loose a solid electrical connection may no longer exist between units of a hardware assembly. Arcing may therefore occur across the tiny gaps thus formed. Shrinkage of wood poles and crossarms almost inevitably results in loose hardware four or five years after a line is built. Loose crossarm braces are very often found to be causing radio interference. A periodical "tightening up" is about the only thorough remedy that can be suggested at present.

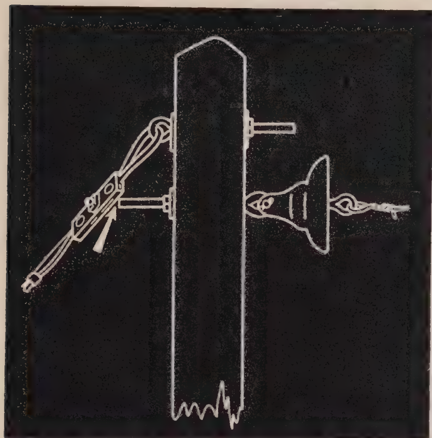
2. *Keep ground wires on poles clear of all ungrounded hardware*—This rule is often violated in connection with lightning arrester ground wires on transformer poles. Particular care should be taken to keep arrester grounds clear of such electrostatically charged objects as insulator pins and switch assemblies, as well as crossarm braces, transformer hangers



Guy wire hardware almost touching metal pole-top insulator pin (rule 3).

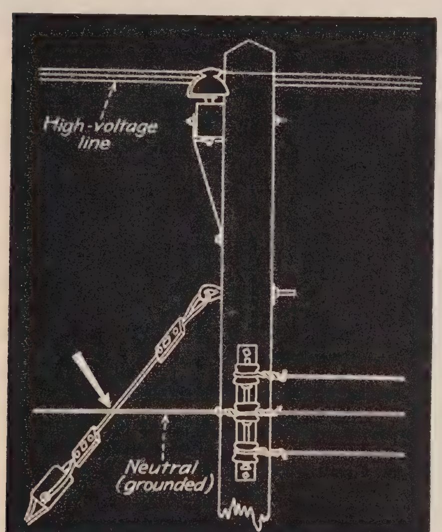


Metal pole top pin or switch base too near pole hat on 7,620-volt line; keep all pole hardware spaced well apart or connect it all together.



Guy wire too near eyebolt; keep all guy wires clear of all hardware (rule 3).

and metal "kickers". If weatherproof insulated ground wire is used staples should not be driven hard enough to crush the insulation. If bare ground wire is used staples should



Intermittent contact between guy and neutral wires; keep guy wires clear of all other wires (rule 3).

be driven tight. Staples within a few feet of a high-voltage lead wire become charged, and will discharge to the ground wire if these rules are not observed.

3. *Keep guy wires clear of all other wires and hardware*—An ungrounded section of guy wire (the section above the strain insulator) becomes electrostatically charged and care should be taken to insure against guy and neutral wires touching or slapping together in windy weather.

4. *Provide solid electrical connection between line and tie wires*—This means *keep tie wires tight.* On circuits of above 5,000 volts, if the line wire is weatherproof insulated, the insulation should be removed at insulator ties and disk insulator dead-ends. If this is not done arcing or "spitting" will occur between the line and tie wires, especially after the insulation has aged a few years.

5. *Avoid the use of any metals which will rust or corrode*—Where rust or corrosion occurs good electrical connection no longer exists. Even such small articles as the cotter pins used in disk insulator assemblies are important in this respect—only the standard brass type should be used. Steel cotter pins or makeshifts should never be substituted. Electrostatic discharge to a rusted or corroded cotter pin will cause considerable radio interference. Metals which ordinarily will not corrode may do so when in contact with a different metal; this principle has, of course, been recognized and taken into account in the design of special devices for making connection between copper and aluminum conductors.

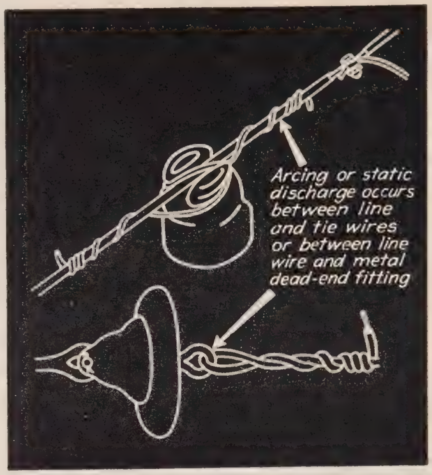
Recently considerable trouble was experienced at the ties on the neutral wire (grounded) of a 7,620-volt rural line. The conductor was stranded aluminum, the ties copper and the neutral support brackets galvanized iron. The cause was found to be "spitting" at some of the neutral wire ties; the lineman could hear the arc by placing his ear close to the tie. Removing the tie wire caused the radio interference to stop. This condition was occurring all along the line and was very difficult to remedy as it appeared to be due not so much to looseness of the tie as to corrosion formed by electrolytic action between the dissimilar metals. A detailed investigation of this condition has not yet been made.

6. *"Haywire" should always be removed when found hanging on high-voltage line wires*—This should be done even if it is on the neutral wire and cannot possibly swing into contact with other wires, as radio interference will result if such pieces of scrap are rusted.

BOTHERSOME INTERFERENCE

In general, the most serious interference to radio reception will be caused by a discharge between two pieces of hardware when one is grounded and the other quite close to a "hot" line wire. These conditions are fulfilled, for example, when the ungrounded mounting assembly of a transformer primary switch almost touches the grounded mounting assembly of a lightning arrester, or when the arrester ground wire almost touches a steel insulator pin.

On the other hand, a discharge between two ungrounded pieces of hardware may cause *comparatively slight* interference. An example of this sort is the arcing that takes place between the two arms of a set of loose crossarm braces or between a loose insulator pin washer and the pin itself. Note, however, that *comparatively slight* should not be interpreted as *negligible.*



Weatherproof insulator at insulator ties and dead-ends on lines above 2,300 volts; remove insulation at these points and use bare tie wire (rule 4).

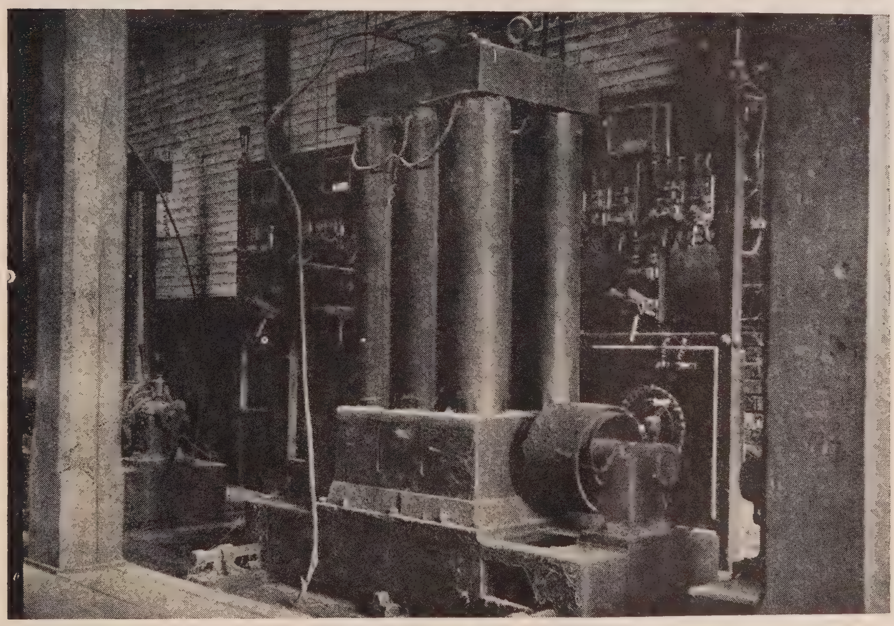
It may be of interest to mention here that radio interference caused by the type of condition being discussed may disappear in wet weather, or may come and go with changes in temperature. During a rain, water may form a temporary "bond" between closely spaced units of hardware, literally quenching the arc. Temperature changes may cause sufficient contraction or expansion of hardware to close a small gap or widen it, causing an arc to start or stop. Ordinarily, the size of the gaps across which these troublesome arcs occur is less than one-eighth of an inch.—*Electrical World.*

An Old Type Switchboard

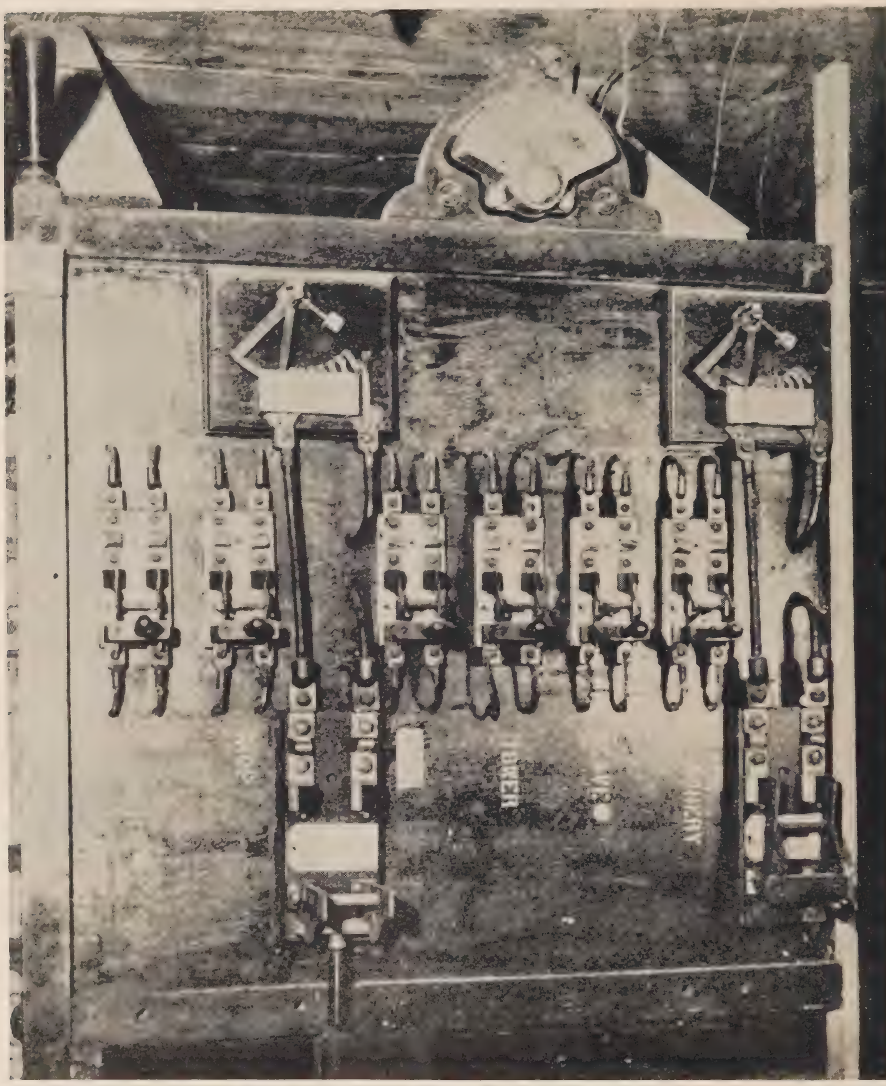
IN *The Bulletin* of May, 1929, we had a short article descriptive of an early installation made in the plant of the Canada Cotton Company, now known as the Canadian Cottons, Limited, at Cornwall, Ontario. The accompanying picture, which is reproduced here, was of an Edison bi-polar d.c. generator that started operation on February 28th, 1883, and remained in service until 1913. It had a capacity of 16 horsepower, and weighed 4,875 pounds. Thomas A. Edison personally supervised the installation and was present when it was placed in service, closing the main switch.

Reference was made to the switchboard which is shown behind the generator. The distributing panel, at the left rear of the generator remained in service until after March, 1931, when it was replaced by modern equipment. A picture of that panel with a more modern type ammeter mounted on top of it is also shown. The panel was made of wood carried on a wooden frame. On this were attached slate bases mounting the quick break switches with link fuses and ammeters. The original generator panel shown at the right rear of the generator was of the same type of construction, viz. wood with field rheostats, etc., mounted on slate bases.

Overlooking the type of construction as compared with present stan-



Edison generator and switchboard installed at Cornwall, Ont., in 1883.



Distributing panel of Edison switchboard which operated from 1883 to 1931.

dards, one is impressed by the generosity in the use of copper. The switches, for which the ratings are not available, appear to have been designed to withstand mechanical usage rather than on the basis of current carrying or interrupting capacity. It will also be noted that some of the original cast terminals have disappeared and either have been replaced by home-made substitutes or dispensed with altogether. All connection screws for the fuses are round head slotted as are those for the ter-

minals, excepting the terminal screws for the main switches and the ammeters which are hexagon headed.

That the board continued to give service during the 48 years of its life without serious trouble is an indication of the allowances made in the construction to avoid dangerous conditions which have since become thoroughly understood. This did not compensate for any dangers that might arise to unthinking persons, which no doubt were recognized and every effort was made to avoid.

The Original Subscription List

ILLUSTRATED herewith is a reproduction of a photograph of the original subscription list by which the sum of $45.00 was collected towards the expense of obtaining the services of Chas. H. Mitchell, Engineer, to report on the possibility of obtaining power from Niagara Falls for distribution to municipalities in Ontario. The record is as follows:

Berlin, Ont., June 2, 1902.

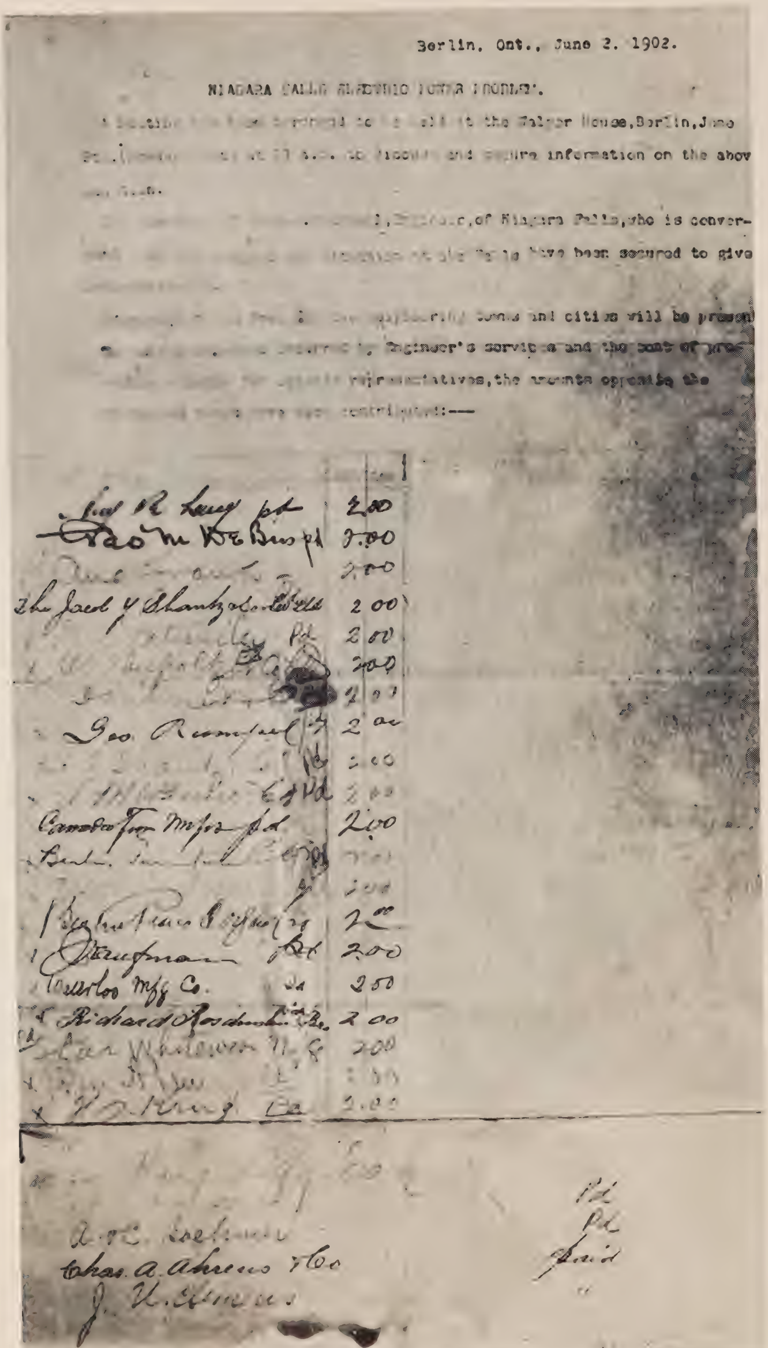
NIAGARA FALLS ELECTRIC POWER PROBLEM

A meeting has been arranged to be held at the Walper House, Berlin, June 9th (Monday next) at 11 a.m. to discuss and secure information on the above question.

The services of Chas. H. Mitchell, Engineer, of Niagara Falls, who is conversant with the subject and situation at Niagara Falls have been secured to give information, etc.

Representatives from all the neighbouring towns and cities will be present. To defray expenses incurred by Engineer's services and the cost of providing a lunch for outside representatives, the amounts opposite the following names have been contributed:—

	Name	*Amount*
	Aug. R. Lang pd.	$2.00
	Geo. M. DeBus pd.	2.00
Pd.	Aug. Frank	2.00
	The Jacob Y. Shantz & Son Co. Ltd. Pd.	2.00
	D. B. Detweiler Pd.	2.00
	G. V. Oberholtzer Co. Ltd. Pd.	2.00
	D. Hibner & Co. Pd.	2.00
	Geo. Rumpel pd.	2.00
	I. E. Shantz & Co. Pd.	2.00
	L. McBrine & Co. Pd.	2.00
	Canada Furniture Mfrs. pd.	2.00
	Berlin Furniture Co. Ltd. Pd.	2.00
	C. H. Hagedorn Pd.	2.00
	Berlin Piano & Organ Co.	2.00
	J. Kaufman pd.	2.00
	Waterloo Mfg. Co. Pd.	2.00
	Richard Roschman & Bro. pd.	2.00
Pd.	Star Whitewear Mfg. Co.	2.00
	John A. Lang Pd.	2.00
	H. Krug Pd.	2.00
	L. Ray Mfg. Co. Pd.	
	C. H. Doerr & Co. Pd.	
	A. & C. Boehmer Pd.	
	Chas. A. Ahrens & Co. paid	
	J. M. Clemens "	



Berlin, Ont., June 2. 1902.

NIAGARA FALLS ELECTRIC POWER PROBLEM.

[illegible] at the Walper House, Berlin, June [illegible] at 11 a.m. to discuss and secure information on the abov[illegible]

[illegible], of Niagara Falls, who is conver-[illegible] have been secured to give [illegible]

[illegible] towns and cities will be present [illegible] Engineer's services and the cost of pro[illegible] representatives, the amounts opposite the [illegible] contributed:—

[illegible] pd	2.00
Geo M DeBus pd	2.00
[illegible]	2.00
The Jacob Y Shantz & Son Co Ltd	2.00
[illegible] pd	2.00
[illegible]	2.00
[illegible]	2.00
Geo Rumpel	2.00
[illegible]	2.00
[illegible] pd	2.00
Canada Furn Mfrs pd	2.00
[illegible]	[illegible]
[illegible]	2.00
[illegible]	2.00
[illegible] pd	2.00
Waterloo Mfg Co. pd	2.00
Richard Roschman	2.00
[illegible]	2.00
[illegible]	2.00
[illegible] Co	2.00

A. & C. Boehmer — Pd
Chas. A. Ahrens & Co — Pd
J. U. Clemens — Paid

The original subscription list.

A.M.E.U. Nominations

The Primary Ballot of the Association of Municipal Electrical Utilities giving nominations for officers for the year 1941, according to the scrutineers' report shows the following names. Those nominated for each office are listed in the order of the nominating votes received by each. The names marked with a star (*) are those that will appear on the election ballots, provided none of the nominees withdraw. The elections will take place on the first day of the winter convention of the association, which will be held at the Royal York Hotel, Toronto, on February 4th and 5th, 1941.

The nominations are as follows:—

PRESIDENT: C. E. Brown*, A. B. Manson*, A. W. Bradt, G. E. Chase, R. H. Martindale.

VICE-PRESIDENT: A. W. Bradt*, V. A. McKillop*, W. R. Catton, S. W. Canniff, C. E. Brown, R. H. Martindale, R. J. Smith, P. B. Yates, W. E. Reesor, G. F. Shreve, R. S. King, Fred Clark.

SECRETARY: S. R. A. Clement*, M. J. McHenry*.

TREASURER: G. E. Conn*, F. A. Archer*, S. E. Preston, S. R. A. Clement, E. B. Easson.

DIRECTORS (from the membership at large): S. W. Canniff*, A. W. Bradt, W. R. Catton*, O. M. Perry*, P. B. Yates*, O. H. Scott*, O. C. Thal* and G. E. Chase* (tie), H. R. Hatcher, R. S. King, G. F. Shreve, R. L. Dobbin, M. W. Rogers, J. E. Teckoe, V. A. McKillop, W. M. Salter, C. C. Folger, R. J. Smith, J. W. Peart, C. A. Walters, R. H. Martindale, E. V. Buchanan, R. S. Reynolds, J. E. B. Phelps, George Boucher, R. J. Cook, E. R. Smithrim, N. A. Anderson, T. R. C. Flint, Charles Wilson, W. D. Stalker, J. C. Keith, L. G. McNeice, R. M. Parkinson, A. H. R. Thomas, R. B. Hanna, R. English, W. D. McCormick, D. E. Charters, W. E. Swartz, A. E. Ditchburn, F. D. Hubbell.

DISTRICT DIRECTORS:

NIAGARA DISTRICT: R. S. Reynolds*, W. R. Catton, J. E. Teckoe*, O. M. Perry and J. E. B. Phelps* (tie), H. R. Hatcher, T. R. C. Flint, N. MacNichol, J. W. Peart, A. E. Ditchburn, P. B. Yates, W. E. Wallace, F. D. Hubbell, C. A. Veigel, V. A. McKillop, A. W. Bradt, S. Watt, E. V. Buchanan, C. R. Southern, W. D. Stalker, W. Gleiser.

GEORGIAN BAY DISTRICT: R. S. King*, W. M. Salter*, H. S. N. Demf, H. Campbell.

CENTRAL DISTRICT: O. H. Scott, G. F. Shreve*, R. L. Dobbin*, H. L. Pringle, P. D. Denyes, C. A. Walters.

EASTERN DISTRICT: W. P. J. Derham*, R. J. Smith*, A. L. Farquharson.

NORTHERN DISTRICT: No nominations.

By the end of November all opposition to C. E. Brown of Meaford as president has been withdrawn as also that to the present secretary, making these two offices filled by acclamation. Other withdrawals are V. A. McKillop of London from the office of vice-president; O. H. Scott of Belleville from director from the membership at large; J. E. Teckoe of Niagara Falls from district director, Niagara district; W. M. Salter of Barrie from

district director, Georgian Bay district and R. L. Dobbin of Peterborough from district director, Central district.

Circus Advertising—1880

Fergus people saw an electric light for the first time in 1880, just 60 years ago. It was an arc light exhibited at one of the small circuses which used to visit the locality in those days. Power was supplied by a portable steam boiler and a 30 horsepower steam engine driving a dynamo, supplying the arc light with direct current. According to the advertising "Its Planetory, Constellated Conflagration of Effulgence and Heaven-born Splendor Exceeds the Full Power of 240,000 Gas Lights."—*Fergus News-Record.*

O.M.E.A.—A.M.E.U. CONVENTION

At the Royal York Hotel, Toronto
February 4th and 5th, 1941

DETAILS OF CONVENTION PROGRAMS WILL BE ANNOUNCED LATER

Reduced Rates for Railway Transportation

The Associations have arranged for reduced railway fares for delegates attending the convention of **fare and one-third plus twenty-five cents** where the regular return fare is greater than seventy-five cents.

Delegates coming to the convention by railway should purchase one-way tickets for **himself and for each person accompanying him,** and obtain from the ticket agent an **identification certificate** form for **each** ticket purchased. He should bring **all identification certificates** with him to the convention to be certified by the Associations.

If **seventy-five or more certificates** are certified, he will then have his certificates **validated by the Canadian Passenger Association** for which there is a **fee of twenty-five cents.**

Holders of **validated certificates** can then purchase their return tickets for one-third the regular one-way rate.

Going tickets and certificates will be issued January 30th to February 5th, 1941.

Properly validated certificates will be honored for tickets for the return journey up to and including February 8th, 1941.

Delegates purchasing return tickets for **seventy-five cents or less** should also obtain certificates to be turned in on arrival. No validation fee is required for these, but they are included in the total certificate count.

The Associations have delegated S. R. A. Clement to certify the certificates. He will be at the Royal York Hotel on the evening of Monday, February 3rd, and all day on February 4th and 5th.

The Special Agent to validate the certificates will be present on February 4th and 5th.

THE BULLETIN

Published by

THE HYDRO-ELECTRIC POWER COMMISSION of Ontario

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Major J. A. Gordon White, D.S.O., M.C.

MAJOR James Alexander Gordon White, D.S.O., M.C., of the Property Department of The Hydro-Electric Power Commission of Ontario, passed away in Toronto General Hospital on the morning of Sunday, November 24th, 1940, aged 52 years.

Gordon was born at Woodstock,

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Vol. XXVII No. 12
December, 1940

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

Ontario, where he received his early education. He then attended McGill University in Montreal, and graduated in 1912 in mining engineering. Following graduation he entered the employ of the Mond Nickel Company at Sudbury where he stayed for one year, then going to the Robert Grace Contracting Company. In June, 1914, he came to The Hydro-Electric Power Commission of Ontario as one of the Hydraulic Department's staff.

In December, 1914, he volunteered in the first Great War being given a commission as lieutenant in the 7th Canadian Mounted Rifles, and was there promoted to a captaincy. He reverted to lieutenant to go to France. Overseas, the squadron with which he went became a divisional cavalry squadron, later part of the Canadian Corps Cavalry. In June, 1917, Lieutenant White was awarded the Military Cross for gallantry, his investiture taking place at Buckingham Palace. Before the armistice in 1918, he became staff captain, and later brigade major. Major White's D.S.O. was for services as major of headquarters of the 2nd Engineer Brigade.

Before leaving England, he took post-graduate work at Caius College, Cambridge. Mr. White again took up his civil duties in May, 1919, returning to the Commission's Hydraulic Department. In 1927 he was transferred to the Transmission Section of the Electrical Engineering Department, and in 1936 to the Property Department as a Right of Way agent.

Upon his return to Canada, and while getting settled down in civil life, Major White began to take an active interest in the welfare of the returned soldier, and particularly of those members of the Hydro staff who had served in the active theatres of the war. Out of his efforts came the formation of the Ontario Hydro Branch of the Canadian Legion B.E.S.L., of which he was the first president. Through his efforts and encouragement this branch of the Legion ranks as one of the outstand-

ing branches in the Dominion of Canada.

He was a member of the royal guard of honour at the unveiling of the Vimy Memorial in France, and on the occasion of the visit of their Majesties last year was in command of a section of the veterans at Exhibition Park, Toronto.

After the outbreak of the present war he volunteered for service, but was medically disqualified. He, therefore, went to hospital for the sole purpose of getting the condition rectified, but unfortunately did not recover.

His funeral was held in Toronto, when a large body of members of the Hydro Branch of the Legion with their colours paid their tribute. A bugler sounded the "Last Post" and "Réveillé".

Dismantling of the 28,000 H. P. Turbines at Chats Falls

By R. O. Standing, Assistant Superintendent, Chats Falls Generating Station, H.E.P.C. of Ontario

IN MOST hydro electric units the chief object of maintenance concern is the turbine runner. Generally speaking, no runner has yet been built to indefinitely withstand the attacks of cavitation and the Chats Falls runners are no exception. In many cases it is highly desirable, and even necessary, to remove the runner in order to provide the required accessibility for first-class welding. The problem here was not so much one of runner rehabilitation by the welding process, with which the Hydro mechanical staffs have had extensive experience, but rather, how to remove the runner from its operating position in the turbine.

There appear to be two methods by which the runner could be removed. Either it could be detached from its shaft and withdrawn through the draft tube or it could be withdrawn in the ordinary way, following a complete dismantling of the generator and turbine. The first method was abandoned, after careful investigation, because (a) the operation would be quite difficult and involve much handling, (b) it would be very desirable to dismantle the whole unit for general inspection and checking of alignment and (c) dismantling fixtures might have, in any event, to be provided at a later date, for reasons other than runner repairs; for example for guide vane replacement. The second method, before adoption, had to be extensively studied, because the turbine head cover (Fig. 2) was too large in diameter to pass through the generator stator (Fig. 1) and therefore either the generator stator would have first to be removed or the head cover

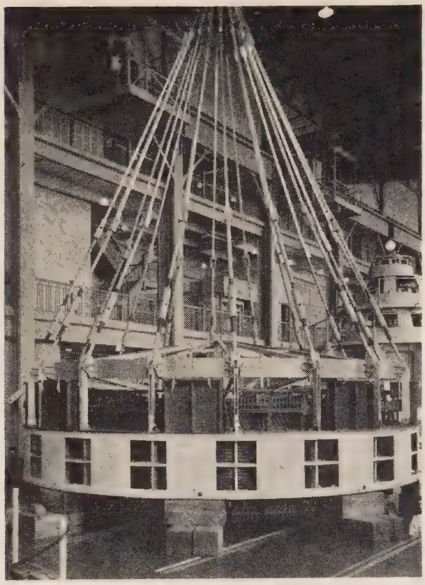


Fig. 1—Ferris-wheel spider connected for lifting 84 ton stator. Eighteen rods are used.

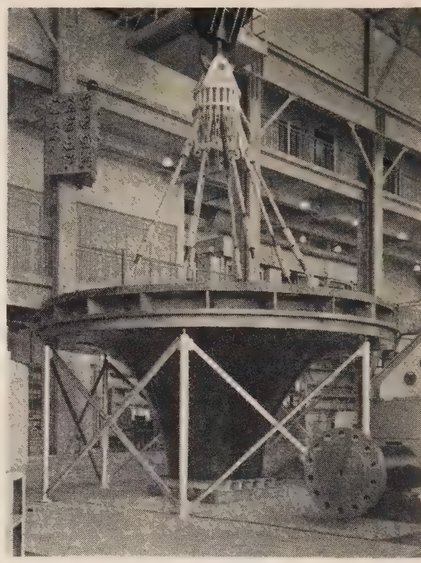


Fig. 2—Lifting head with eight rods connected to 50 ton, water wheel cover, and weight distributing structure for temporary storage.

would require to be split into its original three parts and these would then be withdrawn through the stator.

At first it appeared impracticable to move the stator, a large and relatively flexible ring of 26 ft. in diameter, weighing 84 tons, made up of welded plate sections and therefore much less rigid than the old type cast stator frames, without distortion or damage to the armature winding.

Consideration was then given to the splitting of the head cover into its three original sections by unbolting at the joints. However, all nuts, after tightening, had been spot welded to the bolts and this, together with the generally hazardous nature of removing the separate parts, did not appear to be a satisfactory procedure.

Further study of the problem of removing the stator finally resulted in the decision to remove it and, then in turn, the head cover complete, and the runner, using the specially designed fittings described in this article and without which the dismantling in the manner decided upon could scarcely have been accomplished.

THE FIXTURES IN GENERAL

In large part, the design of the fixtures centered around the economy of making use of material on hand which had been left over from original installation or which had been salvaged. In particular, we mention 18 lifting rods about ten feet long,

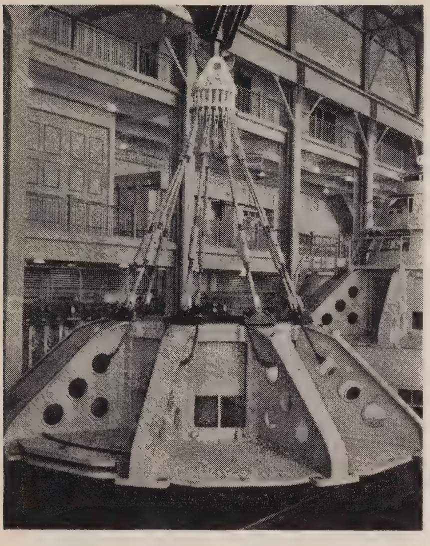


Fig. 3—Lifting head with nine rods and yokes lifting upper bracket with Kingsbury assembly weighing about 50 tons.

2½ inches diameter and capable of fine adjustment in length by virtue of differential sleeve nuts; also a quantity of used 12-inch and smaller channels, a variety of angles and some suitable beams. Fabrication was carried out entirely by the local staff and, principally, by arc welding. In all, some eight special fixtures were built.

EIGHTEEN-ARM, 90-TON LIFTING HEAD, FIG. 3

The capacity of the big hook of the crane is 90 tons and the lifting head actually is capable of lifting much more than this amount with a good factor of safety. The main portion of the head is constructed of electrically welded 1½ in. and 2½ in. plates and special eye-bolts made from 3¼ in. dia. 1020 forging bars. The bolts pass through the lower plate and are tapped (2½ in. dia.) into the upper plate. Lightly welded beads around the bolts at top and bottom plates hold the assembly firm. Links two feet long from pairs of ¾ in. by 5 in. mild steel bars are permanently attached to the eye bolts by means of 1¾ in. dia. Atlas CM steel pins and provide a means of connection to either the extension lift rods shown in Fig. 1 or to the regular lift rods, Figs. 2 and 3. The extension lift rods are 1½ in. square mild steel with special welded end attachments.

The lifting head is extremely versatile. It is used with eighteen arms to lift the stator, with nine arms to lift the upper bracket, and with eight arms to lift the head cover. It carries a plumb bob suspended from its axis to make spotting over its load quite simple.

FERRIS-WHEEL LIFTING SPIDER, FIG. 1

In combination with lifting lugs specially welded to the stator, the spider provides for lifting the stator, which weighs 84 tons and is approximately 26 ft. outside diameter, without producing in it any new stresses whatsoever. The hub of the spider consists of nine 6-inch channels, the rim of 12-inch channel and the spokes of 3½-inch angles. Lugs on the rim are from 12-inch channel and carry the lifting arms and lifting links through a single pin connection in such a manner that when the load is lifted, the spider is supported and stressed through the pins exclusively. The lifting links are from pairs of ⅜ in. by 5 in. mild steel bars and carry 1¾ in. steel pins. These links (and for that matter the

ferris wheel) are required in order to provide clearance for the armature coil ends and connecting rings. Fig. 1 shows the links connected to the lugs.

UPPER BRACKET LIFTING YOKES, FIG. 3

The upper bracket has nine arms and with Kingsbury assembly weighs about 50 tons. Lifting is accomplished by attaching yokes to the arms and connecting nine rods of the lifting head. Compare the difficulty of attaching *four* slings to a *nine* arm load with the simplicity and precision of the method shown! The yokes are made from 1½ in. mild steel rods and welded steel shapes.

HEAD COVER SUPPORTS, FIG. 2

The head cover, like the upper bracket, weighs about 50 tons. It is lifted by connecting the lifting head through eight arms to eye bolts specially located for the purpose. Temporary storage is effected by lowering the unit on to a weight distributing beam structure, and in the provision of a frame of adjustable height to guard against overturning.

Thus, with the use of these special fixtures, we are able to dismantle any of the generating units in the station, with a minimum of labour and a maximum of safety and speed.

Fatigue Tests on Zinc-Coated Steel Wire

By D. G. Watt, Assisting Testing Engineer, H.E.P.C. of Ontario

(Continued from November

DISCUSSION OF TEST RESULTS

Several investigators have drawn attention to the detrimental effect of the hot-dip galvanizing process on the endurance limit of steel wire. In many of these researches, however, the comparison has been made between the endurance limit of the galvanized wire and that of the same wire chemically stripped of its coating or machined and polished to a smooth steel surface.[5, 3]

The injurious influence of the hot-galvanizing process on the fatigue properties of steel wire has been attributed both to surface notching caused by the etching action of the pickling solution and hot zinc on the wire surface and to the presence of the hard brittle zinc-iron alloy layers adjacent to the steel. Chemical stripping of the coated wire may remove the alloy layers, but it does not restore the surface of the steel to the condition prior to galvanizing. Similarly, when the coated wires are machined to the steel and polished, the surface condition is entirely changed and the endurance limit will probably exceed that of the wire before subjection to the coating process. A truer

[5]S. M. Shelton and W. H. Swanger, "Fatigue Properties of Steel Wire," *Research Paper 754*, Nat. Bureau Standards (1935).

Fig. 8.—Contour of parting line between coating and steel. Unetched. Mag. 100×.

a—Coil No. A-7G1-125-283
b— " " B-5G2-125-210
c— " " C-7E-104-201
d— " " D-5E-104-260
e— " " E-6E-104-223
f— " " F-2E-104-264.

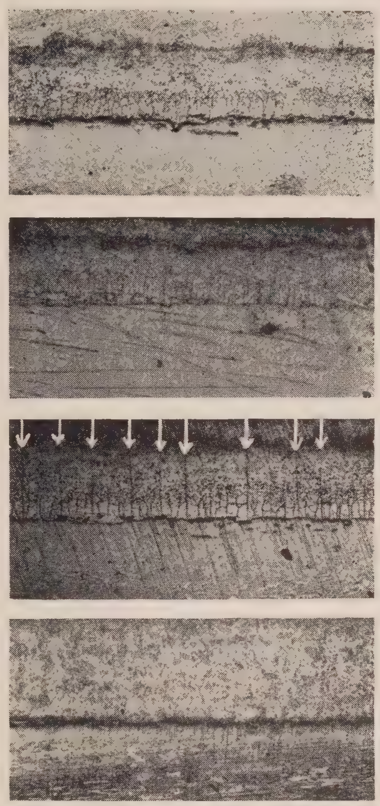


Fig. 9.—Hair cracks developed in hot-dip coatings after fatigue stressing. Etched. Mag. 100×.

a—Coil No. B-5G2-125-210 as received.

b—Coil No. B-5G2-125-210 tensile straightened.

c—Coil No. B-5G2-125-210 after fatigue stressing.

d—Coil No. D-5E-104-259 after fatigue stressing.

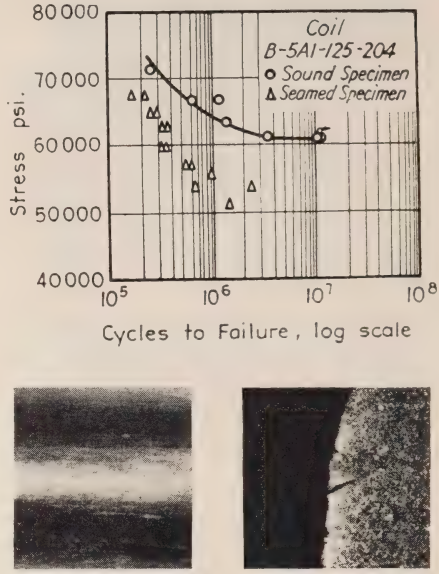
measure of the effect of the hot-galvanizing process on the fatigue properties of wire than is given by either of the above methods is to test the material before and after galvanizing as was done in this investigation.

The micrographs in Fig. 8 illustrating the surface condition of the steel in the zinc-coated wires reveal the

irregularities or notches that have always been associated with the relatively low endurance limits of these materials.

To investigate the influence of cyclic reversed stressing on the zinc coatings, microscopic examinations were made of longitudinal sections before and after subjection to 10,000,000 cycles of reversed stress at the endurance limit. The micrographs in Fig. 9 show that the hot-dip coatings during this treatment developed closely spaced hair cracks perpendicular to and terminating at the steel surface. Similar cracks could not be found in the electro-deposited coatings on specimens subjected to the same treatment. The absence of hair cracks in the electro-galvanized coatings after reversed stressing and the consequent elimination of a source of stress concentration which was active in the hot-dip coatings, may help to explain the higher endurance ratios obtained on the wires coated by the former process. Closely spaced hair cracks, of the type referred to above, could not be detected in the coating on specimens straightened in a tension testing machine, an observation which precluded the possibility that these cracks were produced in the straightening process.

Microscopic examination of the surface of the hot-dip coated fatigue specimens, after test, revealed the presence of circumferential corrugations or stress lines near the mid-span where the highest reversed bending stresses prevailed. Near the free ends of the specimens, where the stresses were relatively low, the appearance



Surface
Mag. 10×

Section
Mag. 50×

Surface seam in wire specimen.
Fig. 10.—Effect of surface flaw on fatigue test results.

of the coated surface remained unchanged after test.

Hot-dip galvanizing depressed the endurance limits of the 170,000 to 190,000 p.s.i. grade lead-annealed wires by 21 to 28.4 per cent. The corresponding reduction for the 220,000 to 250,000 p.s.i. grade wire varied from 15.4 to 20.5 per cent. It might have been expected from the relative ductilities of the two materials that the endurance limits of the harder wires would have suffered the greater reduction in the galvanizing process. For the present the difference in the relative effect of the hot-dip coatings on the endurance limits of the two grades of wire remains unexplained.

From results obtained by other investigators in fatigue tests on steel

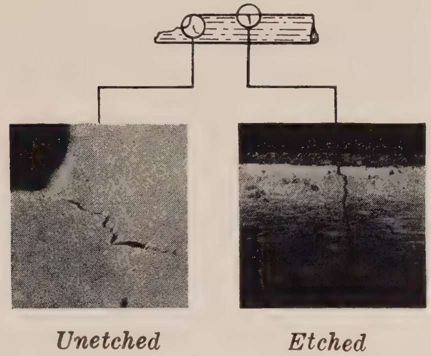


Fig. 11. — Nonmetallic inclusion located at split fatigue fracture and a second fatigue crack in the process of development. Mag. 50×.

wire, it may be shown that an increase in the tensile strength or carbon content of the material is generally accompanied by a decrease in the endurance ratio.[6, 7] The data presented here demonstrated that a similar relationship exists between the endurance limits of zinc-coated steel wires of various strengths, regardless of the method by which the coating is applied. The effect of the tensile strength or the carbon content of the wire on the endurance ratio has been partially attributed, by some authorities, to surface decarburization.[8] Traces of this condition were found in some of the sample groups but it was not common to all of the wires tested.

The utility of the fatigue test for detecting surface flaws on wire is illustrated by the results obtained on the lead-annealed coil No. B-5A1-125-204. The test values, plotted in Fig. 10, fall into two groups. Through one of these an *S-N* curve was drawn which agreed closely with those obtained on three coils of wire of a corresponding grade and diameter and drawn from the same melt of steel. The second group roughly defined a curve located considerably below the aforementioned one, all of the points on which indicated failure at less than 2,600,000 cycles of reversed stress. Subsequent examination of the specimens revealed that all of those which gave low and erratic values in the test contained one or more longitudinal surface seams similar to that illustrated in Fig. 10. The specimens which defined the normal fatigue curve showed no evidence of this condition. Visual examination of the coil from which the above specimens were obtained revealed that surface seams occurred intermittently along a considerable portion of its length.

A few of the fatigue specimens broke with a split type of fracture. Microscopic study of these fractures invariably revealed the presence of elongated nonmetallic inclusion located near the shoulder of the break. A micrograph illustrating the condition in the vicinity of such a fracture is shown in Fig. 11. In this particular specimen a fatigue crack, in the process of development, was detected about ¼ in. from the point where failure occurred.

Although the twist and bend test results could not be directly correlated with the endurance limits of the wires,

[6]A. V. de Forest and L. W. Hopkins, "The Testing of Rope Wire and Wire Rope," *Proceedings*, Am. Soc. Testing Mats., Vol. 32, Part II, p. 398 (1932).

[7]Discussion by H. J. Godfrey of paper by C. P. Wampler and N. J. Alleman, "Fatigue Tests of Wire," ASTM BULLETIN, No. 101, December, 1939, p. 18.

[8]E. T. Gill and R. Goodacre, "Some Aspects of the Fatigue Properties of Patented Steel Wires," *Journal*, Iron and Steel Inst., Vol. II, p. 293 (1934).

the tests proved useful in that they furnished a convenient method of assessing the uniformity of material and detecting brittleness therein. The twist test results appeared to be strongly influenced by the surface condition and ductility of the outer fibres of the wire. Hot-galvanizing, in general, depressed the twists and bends to failure obtained on the lead-annealed wire, the effect being more marked in the wires in group B than in the harder wires in group A.

Special attention was directed to the type of fractures obtained in the twist and bend tests. Poor fractures of a split type generally occurred in specimens containing non-metallic inclusions.

Summary

The more significant points deduced from the test data presented in this paper include the following:

1. Within the limits of tensile strength investigated, namely, 110,000 to 256,000 p.s.i., the endurance limits of the zinc-coated wires increased with the tensile strength while the endurance ratio diminished.

2. Hot-dip galvanizing depressed the endurance limit of the lead-annealed wire 15.4 to 28.4 per cent, depending to some extent on the grade.

3. No perceptible difference was observed between the endurance limits of the wire hot-galvanized with four and three and one half dip coatings.

4. Reduction by drawing, within the range of wire sizes investigated, increased the endurance limits of the wires in both the lead-annealed and zinc-coated conditions.

5. Steel wires coated by electrolytic processes showed, in all three grades, somewhat higher endurance ratios than were obtained on wires coated by hot-dip methods.

6. Hot-dip coatings developed, under reversed stressing, closely spaced hair cracks perpendicular to and terminating at the surface of the steel. In the electro-deposited coatings no evidence of such cracks could be found after similar treatment.

7. Lack of uniformity in the test results and the abnormal fractures obtained on defective wires, containing surface seams or nonmetallic inclusions, demonstrated the utility of the fatigue test for detecting faulty materials.

8. Although no definite correlation could be observed between the bend and twist test results and the endurance limits of the wire, these tests proved useful in assessing the uniformity of the wire and detecting brittleness therein.

Acknowledgments

The author is indebted to The Hydro-Electric Power Commission of Ontario for permitting publication of these data. He also wishes to acknowledge the assistance of E. J. Mason who prepared the micrographs.

How 'M I Doin'?

By Dr. Morris S. Viteles, Philadelphia Electric Company

ONE of the fundamental distinctions in human conduct is that between "knowing" and "doing." Although knowledge is basic to correct performance, knowledge of how to do a task is in itself no guarantee that the task will be well done. Because of this, job training, as valuable as it may be, is in itself no panacea for insuring satisfactory and safe performance on the job. Trained men, who know how to do the job, still require stimulation and leadership to encourage the transformation of knowledge about the job into effective and safe practices on the job.

The self-audit plan described in this paper, used in connection with the Job-at-Hand Training Program of the Philadelphia Electric Company, represents a promising method for helping to convert knowledge into action. The fundamental idea behind this plan is that even the man who knows how to do the job, and who is eager to do it well, frequently slips into careless or neglectful ways of doing the job without becoming aware of the change in working habits which has taken place. The functions of the self-audit plan are to direct the man's attention towards his own work; to encourage him to review his own working practices and to correct any faults which he discovers in them through the use of self-audit check sheets.

The viewpoint underlying this approach can be illustrated by reference to what happens to driving habits. Every man, when he first learns to drive a car, makes a solemn oath that he will do everything possible to drive it safely. He therefore starts by carefully signalling other drivers before making a stop; by refraining from passing other cars on the crest of a hill, and otherwise adhering to safe driving practices.

Slowly, with the passage of time, a change occurs in the driver's operating habits. He starts taking the inside lane at corners which seem safe; to pass cars close to the top of a hill, and so on. These changes take place so slowly that the driver is unaware of the fact that he is casting off fundamental cautions in driving.

One day, the driver barely avoids an accident in cutting a corner or passing a car at the crest of a hill. As a result, he suddenly becomes acutely conscious of the fact that he has been taking chances for many days. Having become aware of this, and still shaken by the near-accident, he again returns to his earlier and safer driving habits.

Everyone will recognize that this is a fair description of what happens to many drivers. There is good reason to believe that a periodic check of driving practices by the man who operates a car can do much to prevent him from unconsciously slipping into faulty and dangerous operating

habits responsible for serious as well as near-accidents.

What has been said of driving also applies to working practices on the job. Having been taught and having practiced the correct methods of work, the employee does not consciously and willingly undertake to use other than correct and safe methods of work. It seems reasonable to believe that a man who, through the use of a self-audit check sheet, systematically and conscientiously reviews his working methods, and discovers a tendency to shortcut or neglect efficient and safe practices, will be more than willing to return to the better methods of work.

The general character of the self-audit program is illustrated in that used by the Appliance Service Division. This calls for the distribution, once a month, for each of three months, of a self-audit check sheet with questions covering automobile operation, customer contacts, dispatching procedures, conduct on customer premises, and other work practices. These monthly self-audit check sheets will be followed, at the end of six months, by a general self-audit check sheet reviewing all of the practices covered in the three sheets issued at monthly intervals. The general purposes of the self-audit program are described in a covering letter, sent to each employee with the first of the self-audit check sheets by the general superintendent of the Appliance Service Division. In this, the letter emphasizes the self-corrective and confidential nature of the self-audit check sheet:

"The attached check sheet," writes the general superintendent, "can be used by you to determine whether you are 'slipping' on any detail of your job, thereby giving you an opportunity to correct anything in your operating habits which is in need of correction.

"This self-audit sheet is intended for your own information and for your own use only. You will not be requested to show it to any of your associates or superior and it need not be discussed with them. You may destroy this sheet when it has served your purpose. All that we ask is that you try it and that you play fair with yourself as you consider each of the items included in the questionnaire."

Extensive use is being made of self-audit procedures by the Station Operating Division, Transportation Division, Stores Division and, in various units of the Gas Operations Department of the Philadelphia Electric Company. In addition to its use in specialized job situations, the self-audit program has been extended to cover approximately 2,500 employees operating company cars, or authorized to operate their own cars on company business.

One of the chief advantages of the self-audit technique is that it is applicable to practically every kind of work operation and on almost every kind of job. For example, in the self-audit program developed for the Appliance Service Division practices covered by check sheets include those used in handling customers as well as those of the manual type. In earlier training program, the self-audit plan has been employed in help-

	1	2	3
1. Do I make sure that vehicles jacked up for repairs have proper support?			
2. Do I use goggles whenever necessary?			
3. Do I check hammer handles to make sure that the head is sufficiently tight before using?			
4. Do I select the proper and safe tool for each job?			
5. In using the chain hoist, do I make sure that the hook is heavy enough for lifting the load safely?			
6. Do I safeguard against both fire and personal injury when using torches?			
7. Do I take care in lifting heavy material so as to avoid strain or injury?			
8. In using the chain hoist, do I make sure that the hook is securely fastened?			
9. In changing large tires do I make sure that the tire is properly seated in the bead?			
10. Do I refrain from leaving tools around where they can be tripped over?			
11. In using the chain hoist, do I center the hoist over the load?			
12. In changing large tires of the lock ring type, do I make sure that the lock rings are properly installed?			
13. Do I replace tools where they belong after they have been used?			
14. In using the drill press, do I always carefully clamp the material to the table of the drill press?			
15. In using the drill press do I make sure to select the proper speed for the operation to be performed?			

A typical self-audit check sheet (reverse side).

ing receptionists and customers service employees to review their habits with respect to the maintenance of good appearance as well as with respect to procedures used in handling customers. Not only is the self-audit program applicable to a large variety of work activities; it has the additional merit of being inexpensive to operate.

It is apparent that all the self-audit program does is to encourage

each man to ask himself the question "HOW 'M I DOIN'?" and to urge him to answer this question in an honest and straight-forward manner. Because the check sheets are not collected, there is no way of knowing (a) what percentage of the workers do as they are asked to do; (b) whether they make an honest attempt to answer the questions truthfully, and (c) whether they act upon the questions after they have been answered.

In spite of this, there seems merit in using the self-audit plan, primarily because it is based upon fundamentally sound assumptions:

(1) The first of these is that every normal man likes to know how he is doing. The popularity of "Information, Please," and similar radio programs attest to this fact. There is reason to believe that people listen to this program not primarily to learn something new, but to check their information against that of the "experts". The greatest satisfaction in listening to such a program comes not from picking up a new fact, but from being able to answer a question which "stumps" the expert. It is believed that this curiosity concerning oneself will apply to a quiz concerning one's job as well as to a radio program, and will lead the employee to answer a few simple questions concerning his working habits with a view of finding out how he actually stands with respect to his working practices.

(2) The second assumption is that having discovered faults in their working practices, men will make an honest effort to correct them. Underlying this assumption is the belief that men are fundamentally interested in doing a good job—that one can safely place dependence in the worker's desire to do a good job as a positive force for efficient and safe work. The self-audit procedure is designed to give each man the information he needs as a basis for correcting faults in his working practices.

(3) The third assumption is that the man who knows that he is doing well will attempt to do even better. Experiments in the psychological laboratory merely confirm what the skilled foreman in industry already knows, that knowledge by the man of results obtained during work tends to improve performance on the job. From the self-audit check sheet the man on the job obtains that information about his own performance which, in itself, constitutes an incentive to better performance. In addition, this self-knowledge furnishes a stimulus for the exercise of creative effort in finding even new and better ways of doing the job safely and well.

Such are the assumptions underlying this self-audit program. Devices for stimulating workers to efficient and safe performance on the job include procedures ranging from cajolery to threats; from an emphasis upon fear of discharge to promise of promotion; from suspension to the award of pleasure trips; and so on. Among them are the negative procedures which surround the worker with a wall of discouragement and those which provide positive encour-

agement to the man at work to participate with others in doing a job well. The experience of practical foremen and supervisors has clearly shown that although effort can be induced for a time by both negative and positive influences, long-continued effort, such as is called for in modern industry, can be kept at a high level of efficiency and safety only by the positive urge. The self-audit plan has the distinct advantage of furnishing such positive stimulation to good performance. It tends to place responsibility for such performance where it belongs—on the man at work, and to encourage active effort on his part to live up to this responsibility.—*Edison Electric Institute Bulletin.*

C.E.S.A. Standard Specification for Paper Insulated, Lead Covered Cable

By C. E. Schwenger, Engineer of Distribution, Toronto Hydro-Electric System and Chairman, C.E.S.A. Committee on Insulated Power Cable

THE Canadian Engineering Standards Association has issued a specification for paper insulated, lead covered cables for all operating voltages up to 25,000. This specification is known as C.68.A., issued in November, 1940, and has been prepared to insure the manufacture of high quality paper insulated, lead covered cables suitable for operation at the standardized rated voltages shown in the specification. It is intended to cover all sizes and classes of impregnated paper insulated, lead covered cables, which are to be used for the transmission and distribution of electrical energy under average conditions.

This specification is the result of meetings of a Committee representative of all parts of the Dominion, which was formed in 1931 following requests from cable users for a Canadian Standard covering lead covered cables. At the time the Committee started its work, a large number of specifications were in use in Canada, differing widely from one another in many respects. It was felt that no complete Canadian standard could be evolved by averaging out the various specifications, nor was it possible or desirable to prepare specifications entirely independent of specifications then being used in other countries. The Committee, therefore, studied specifications of the then existing standards associations, such as the

British Standards Institution, Insulated Paper Cable Engineers Association, Association of Edison Illuminating Companies and others, and produced a tentative specification in March, 1932.

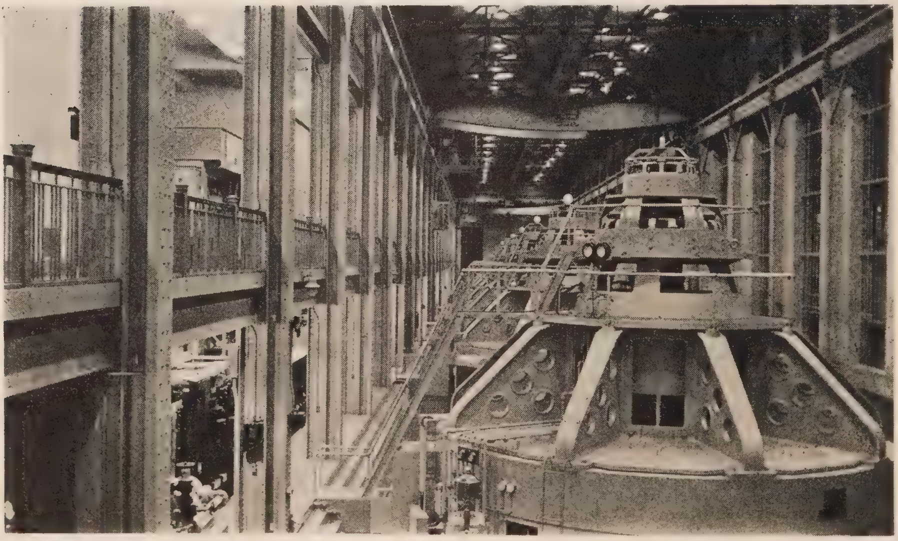
As the result of the study of these specifications and the tentative C.E.S.A. Specification, several meetings of the Committee were held. The draft went through several revisions culminating in its present form, C.68.A., adopted in 1940.

The present specification in its tentative form was used by several Canadian manufacturers of lead covered cables for several years before its final adoption in 1940, and many users have, therefore, in service cables built on this specification, with satisfactory results.

It is felt that the use of this specification will accomplish the purpose for which it was originally intended, namely, the clearing up of much misunderstanding in the calling of tenders for cable and at the same time effecting considerable economy."

* * * *

Copies of the C.E.S.A. Specification for Paper Insulated, Lead Covered Cable are available at a price of $1.00 each, and may be obtained from the Canadian Engineering Standards Association, 3010 National Research Building, Ottawa, Col. W. R. McCaffrey, Secretary.



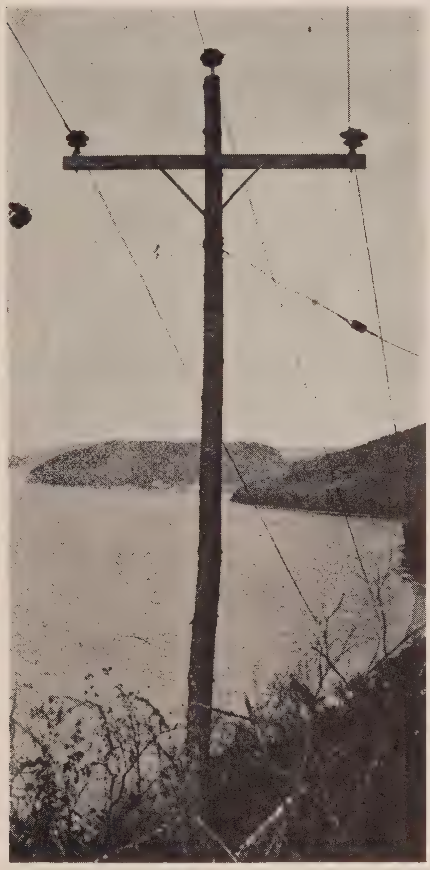
Generator room, Chats Falls development.

It Has Happened Before

THE resourcefulness of patrolmen in emergent conditions was well exemplified recently. Power service, like the show, must go on in the Lake Nipigon-Geraldton mining region, as elsewhere.

Due to rock slides and other contributory damages, a pole carrying a 44,000 volt line, serving important mining loads and pumps, failed. This

Approaches for repairs and replacements, by patrolmen, of poles damaged and removed from the 44,000-volt line, also abandoned broken pole 75 feet lower are recognized. Location is near Canadian National Railway right-of-way, Orient Bay.



Live tree, top and limbs removed, temporarily carrying 44,000-volt services—a quick repair job—near lake Nipigon.

pole was on a rock escarpment some two hundred feet high, where access was difficult. Emergently, the patrolman, in clearing a new route higher up the cliff trimmed up a suitable standing live tree, placed the cross-arms and other head works on it,

guyed it, and restored the conductors in quick time.

The photographs show the line with temporary repairs.—A.E.D.

Two New Superintendents

Gravenhurst and Huntsville, two municipalities in the Muskoka division of the Georgian Bay system have recently appointed new superintendents. James Page, formerly of the Orillia Water, Light and Power Commission has been given the position in Gravenhurst replacing Don Longhurst who met with a fatal accident last summer. Morris Soden of the Public Utilities Commission of Midland received the appointment in Huntsville replacing George Ralston who has retired.

Convention Programmes

THE Annual Meeting of the Ontario Municipal Electric Association and the Winter Convention of the Association of Municipal Electrical Utilities will be held at the Royal York Hotel, Toronto, on Tuesday and Wednesday, February 4th and 5th, 1941. The programmes of the two associations in so far as arrangements have been completed are outlined in the following. There will be two joint sessions of the two associations, namely, on the afternoon of each day; each association will hold separate meetings in the mornings. They will follow the general practice of meeting together for the convention luncheons and dinner, the luncheon on Wednesday, February 5th, being attended by the Electric Club of Toronto as guests of the two associations.

* * * *

Accident Prevention Meeting

On the evening preceding the convention, Monday, February 3rd, there will be a dinner meeting at the Royal York Hotel, beginning at 6.00 o'clock, of the Electrical Employers Association of Ontario. There will be a number of short addresses on the work of Accident Prevention, and also a general Round Table Conference. Officers of the Electrical Employers Association and also its Managing Committee will be elected at this meeting.

* * * *

O.M.E.A.

The programme of the Annual Meeting of the Ontario Municipal Electric Association, and also those sessions that will be held jointly with the Association of Municipal Electrical Utilities will be as given below.

MONDAY, FEBRUARY 3RD

Evening at 6.30 o'clock.

Executive Committee dinner, followed by Executive Committee Meeting.

TUESDAY, FEBRUARY 4TH

Morning.

9.00 o'clock, Registration.

10.00 o'clock, Convention Session.
Minutes.
President's address.
Secretary's and Executives' Report.
Treasurers' Report.
Resolutions.

Afternoon.
12.30 o'clock, Convention Luncheon held jointly with the A.M.E.U. Address, by Grattan O'Leary, Ottawa.

2.00 o'clock, Convention Session held jointly with the A.M.E.U. Showing of the Hydro Sound Film "The Bright Path".

Address, "Review of Hydro Operations for 1940 and Forecast for 1941" by Dr. T. H. Hogg, Chairman, The Hydro-Electric Power Commission of Ontario.
Discussion.

Evening.
6.30 o'clock, Convention Dinner held jointly with the A.M.E.U.
Address.
Musical entertainment.

WEDNESDAY, FEBRUARY 5TH
Morning.
9.30 o'clock, Convention Session.
Reports of Committees:
Credentials.
Resolutions.
Finance.
Convention.
Report of Election of District Directors.
Election of Officers.
Unfinished Business.
New Business.
General Discussion.

Afternoon.
12.30 o'clock, Convention Luncheon held jointly with the A.M.E.U. to which the Electric Club of Toronto has been invited.
Address, "Merchant Shipping in War Time", by William Baird, Steamship Passenger Traffic Manager, Canadian Pacific Railway, Montreal, Quebec.

2.30 o'clock, Convention Session held jointly with A.M.E.U.
Paper, "Utility Transportation Equipment", by H. D. Rothwell, Assistant Engineer, Municipal Engineering Department, and Chairman of the Truck Committee, The Hydro-Electric Power Commission of Ontario.
Discussion.

Executive Committee Meeting. The new Executive Committee will meet immediately following the close of the afternoon session.

* * * *

A.M.E.U.

The programme of the Association of Municipal Electrical Utilities will follow the order outlined below. For such parts as are held jointly with the Ontario Municipal Electric Association, the reader is referred to the O.M.E.A. programme outlined above.

TUESDAY, FEBRUARY 4TH
Morning.
Registration.
10.30 o'clock, Convention Session
President's address.
Auditors' Report.
Reports of Committees.

Afternoon.

12.30 o'clock, Convention Luncheon with O.M.E.A., see O.M.E.A. program.

2.00 o'clock, Convention Session. Election of Officers for 1941.

Joint Session with O.M.E.A., see O.M.E.A. programme.

Evening.

6.30 o'clock, Convention Dinner with O.M.E.A., see O.M.E.A. programme.

WEDNESDAY, FEBRUARY 5TH

Morning.

8.30 o'clock, Breakfast Meeting and discussion conducted by the Committee on Accounting and Office Administration.

9.30 o'clock, Convention Session. Paper, "Power Arcover Damages, Overhead Line Conductors" by G. A. Matthews, Inspection and Equipment Engineer, Electrical System, Detroit Edison Company, Detroit, Michigan. Discussion.

Paper, "The Fluorescent Lamp, Its Auxiliary Equipment and Characteristics" by G. F. Mudgett, Manager Illumination Dept. Canadian Westinghouse Co. Ltd., Hamilton, Ont.
Discussion.

Afternoon.

12.30 o'clock, Convention Luncheon with O.M.E.A. and the Electric Club of Toronto, see O.M.E.A. program.

2.30 o'clock, Convention Session with O.M.E.A., see O.M.E.A. program.

* * * *

A.M.E.U. Elections

The elections of officers for the year 1941 will be on Tuesday, February 4th. Delegates will obtain their ballots when registering or before the opening of the convention session on the afternoon of that day. Immediately after that session opens, the ballot will be closed and the scrutineers will make their report before the session adjourns. The ballots will show the following as candidates:

PRESIDENT:

C. E Brown, Meaford, Acclamation.

VICE-PRESIDENT:

V. A. McKillop, London, Acclamation.

SECRETARY:

S. R. A. Clement, H.E.P.C. of Ontario, Toronto, Acclamation.

TREASURER:

F. A. Archer, H.E.P.C. of Ontario, Toronto.

G. E. Conn, H.E.P.C. of Ontario, Toronto.

DIRECTORS (From the Membership at Large, Three to be elected):

S. W. Canniff, Ottawa.
W. R. Catton, Brantford.
G. E. Chase, Bowmanville.
O. M. Perry, Windsor.
O. C. Thal, Kitchener.
P. B. Yates, St. Catharines.

DISTRICT DIRECTORS:

Niagara District—
J. E. B. Phelps, Sarnia.
R. S. Reynolds, Chatham.

Georgian Bay District—
H. Campbell, Wingham.
H. S. N. Denef, Hanover
R. S. King, Midland.

Central District—
P. C. Denyes, Campbellford.
C. A. Walters, Napanee.
Eastern District—
W. P. J. Derham, Arnprior.
R. J. Smith, Perth.
Northern District—
To be elected.

* * * *

Reduced Railway Fares

The associations have arranged for reduced railway fares for delegates and their families attending the convention of fare and one-third, plus twenty-five cents. Delegates travelling by railway will purchase one-way tickets to Toronto and obtain from the ticket agent an identification certificate for each ticket purchased. On arriving at the convention, the delegates will have the certificates certified and validated when there is a fee of twenty-five cents per certificate validated. Holders of validated certificates can then purchase return tickets at one-third the one-way rate. At least seventy-five certificates must be certified before any will be validated. The reduced fares apply only where the going fare is seventy-five cents or more (note error in notice in November Bulletin). Where the going fare is less than seventy-five cents, delegates should obtain identification certificates with their return tickets at the regular rate. These certificates should be turned in to be certified at the convention, as they will be counted in the total, but will not require validation fee.

Going tickets will be sold from January 30th to February 5th, and validated certificates will be honoured for the return journey up to and including February 8th. More complete details will be given the delegates with their convention notices.

* * * *

Hotel Rates

The Royal York Hotel is giving the same convention rates as formerly, viz., \$3.50 per person, single and \$3.00 per person if two in a room.

The Role of Science in the Electrical Industry

By M.W. Smith, Vice-President in Charge of Engineering, Westinghouse Electric and Manufacturing Company, Pittsburg, Pa.

THE story of the electrical industry is one of growth in giant, breath-taking strides and great technical advances. Turbine-generator units have progressed to the stage where ratings of 100,000 kv-a. at 3,600 r.p.m. and 300,000 kv-a. at 1,800 r.p.m. can now be built. Hydraulic generators, the size of which may ultimately be limited by manufacturing facilities because of their large diameters, have exceeded 100,000-kw. rating. Efficiencies of some of the large hydrogen-cooled turbine generators, synchronous condensers, and frequency changers have approached 99 per cent in individual units. Transformers have increased to present-day ratings of over 150,000 kv-a. per bank, and efficiencies of well over 99 per cent have been realized. Circuit breakers are capable of interrupting several million kilovolt-amperes — equal to that of the short-circuit capacity of some of the large interconnected systems. Lightning arresters are available with sufficient capacity to handle a direct lightning stroke of over 100,000 amperes and yet limit the voltage to safe values.

Behind this growth, the rate of which has shown no diminution since the birth of the industry, lies a significant, important fact. The industry has consistently accepted and adapted to its own use the new ideas and developments of science. In fact the industry has fostered and encouraged fundamental research to the point that the research laboratory has become an integral part of the industry itself. It also recognizes the value and importance of the scientific accomplishments of the universities and other research institutions, and maintains a close contact with their work.

Efficient Use of Science Presents Many Problems

The task of the industry is not only to uncover new principles and make new discoveries, but also to determine which ones can be put to practical, profitable use, and how. It is difficult to recognize the potential value of new discoveries and to determine at an early stage the possibilities of applying them to industrial processes and products.

The Problem of Timing

The rate of application of new ideas is not dependent solely upon the time necessary to conceive and develop them. It is also influenced by the time required for public acceptance. Household refrigeration, the basic principle of which is very old, required a relatively long time for both instrumentalities and public acceptance.

During the first two decades of radio the efforts of radio engineers were directed toward developing methods by which radio could be used as a means of private communication. It remained for a new idea, the opposite of this notion, to allow radio to assume its present stature. Public acceptance of radio broadcasting was almost instantaneous.

The course of carrier current also supports this point. In the middle 20's carrier current came into successful use for communication along transmission lines. Then came a quiet period of several years in its development, followed about 1935 by an intensified activity which shows no signs of any immediate slackening. The need for high-speed relaying of long lines, the development of better tubes, and other changes in the industry spurred engineers to adapt the fundamentals of carrier current to relaying and supervision as well as communication.

Spot welding has been a practical, though limited, industrial tool for many years. However, some six or eight years ago, the idea was conceived of using the ignitron to control exactly the duration of the welding current. Since that time, spot welding has grown enormously both in total use and in diversity of applications. The ignitron, incidentally, was originally developed not with welding in mind but to increase the reliability of mercury-arc rectifiers.

The Problem of Obsolescence

The industrial laboratory poses the inexorable problem of obsolescence. Fortunately the leaders of the electrical industry have taken the far-sighted view that, in order to make sound progress, the seeming ruthlessness of obsolescence must be accepted.

The discovery of a new fact in science may completely upset an existing design. Even though the style or performance of a product may not be greatly modified, the practice of the art or process by which it is produced may be radically changed. With the steep rise of welding not long ago, in a few short years the method of constructing most large machines swung from casting to welded fabrication. Neither the appearance nor the performance of the machines was fundamentally altered by this change; the principal motive is economy of time and of construction cost.

It behooves all managements to keep themselves keenly alive to the necessity of meeting changes resulting from progress. Of all competition, there is none quite so ruthless as that which replaces.

Editor's Note:

(At this point the author outlines how in the early stages of radio broadcasting, several plants grew up for making of radio head sets which business was practically ruined by the loud speaker; how the heavy production in batteries was curtailed by the development of plate-battery eliminators; the development of the copper-oxide rectifier, and later the development of the a.c. tube completely changed the design of radio receivers. He then shows how the resurrection of some of the older ideas has resulted in the popular battery-operated portable set which

has created a new market. He also traces the effect on industry due to changes in lighting through the kerosene lamp, the gas mantle, the electric lamp to the gas discharge and fluorescent units.)

It is still too soon to predict to what extent they will become the universal illuminants, but there is more than a hint that illuminant evolution is not at an end. No one in the industry thinks for a minute that the more efficient light sources presage a decrease in the requirements for energy or equipment. On the contrary, as in the past, this improvement should promote further expansion.

INDUSTRY FINDS MANY BENEFITS FROM ORGANIZED RESEARCH

The industrial laboratory has served the march of electrical progress in many ways. Not the least of these is that it has served to bring the scientist, the design engineer, and the application engineer into closer contact. They now talk the same language and use the same tools. Universities are giving more attention to the training of industrial scientists, and, within the last few years, important meetings have been devoted to discussions of the application of physics to industry.

The co-operation of university and industrial scientific effort has also contributed much to the progress of development by bringing scientists of different training closer together on specific problems. For instance, much of the recent progress in the improvement of insulation for electrical apparatus has resulted from the combined efforts of physicists, chemists, and electrical engineers working harmoniously in close-knit groups.

Joint Research Between Manufacturer and Supplier

Another co-ordinating function of the industrial laboratory is the co-operative work between electrical manufacturers and the suppliers of raw materials. As a result greatly improved materials have been developed. These in turn enable the electrical manufacturer to build more reliable and more efficient apparatus, which can be extended into new and larger fields of application.

Industrial Research Shortens Time Between Discovery and Use

Another important accomplishment of the industrial laboratory has been to effect a marked reduction in the time between the discovery of a new idea and its commercial application.

Even today, however, special attention must be given to this phase of the problem: After the research work has been completed and the theory or principle of operation has been verified, there still remains the decision as to the commercial possibilities of the new device or product. Usually sufficient information is not available at this stage on which to base an intelligent decision. Information as to probable costs (including equipment investment), processes, production methods, market analyses, and distribution methods must be obtained before a decision to manufacture and sell can be made. This requires that the new product be carried through some preliminary stage of development, where a study of these

factors is made. Usually this takes the form of some kind of pilot-plant activity under the direction of a special experimental or development group that has the responsibility of carrying new products through this incubation stage following the completion of research work. This form of development is particularly conspicuous in the chemical industry.

Patent System Stimulates New Developments

Our patent system has had a stimulating influence on industrial research and developments in the electrical industry that should not be overlooked. It costs money to develop and exploit inventions. The protection afforded by patents provides an incentive to develop new things under conditions such that they may be exploited long enough to become established. Quite often a strong urge toward a particular development seems to become manifest and inventive effort starts simultaneously in many places. This seeming chaos that theorists would like to control from some central throne eventually turns into true co-operative effort through the practical necessity for cross-licensing of patents before a useful product can be obtained. Television is a present-day example. Patents themselves are published and the protection afforded does away with the necessity for secrecy. The new progress that has been made impinges upon other minds, thereby starting new chains of ideas that result in co-ordinated group effort leading to rapid progress.

Without the protection provided by patents, capital would be reluctant to venture into new fields. Industrial research would become secretive, and because of the resulting lack of co-operation and co-ordinated group effort, our progress in technical accomplishments and standards of living would be seriously retarded.

Electrical Industry Draws From All Basic Sciences

Contributions to the development and progress of the electrical industry have come from practically every branch of the basic sciences. This is not surprising when we consider the large variety of materials used in the manufacture of electrical equipment.

Metallurgy

Improvement in electrical apparatus is largely dependent on the improvement made in the properties of the materials used. This applies to both physical and chemical properties of various kinds. The limitations in physical properties of materials are most likely to be encountered in high-speed rotating machinery such as steam turbines, where centrifugal and steam forces are likely to be large under conditions of high temperature, which in turn tends to lower permissible stress limits.

Research work done in recent years by both electrical and steel manufacturers to determine and improve the fatigue, creep, corrosion, and other physical properties of various alloy steels used in highly stressed machines has resulted in such marked advances in design that output ratings have been more than doubled at the highest operating speeds in less than five years.

The electrical industry has also called on the metallurgist for new and improved magnetic steels and alloys. Magnetic steel, particularly electrical sheet steel, has been a subject of continued research by both electrical and steel manufacturers. This has involved studies of molecular and grain structures as well as of chemical compositions and purity. This work has resulted in a steady decrease in iron losses in the cores of transformers and machines of such magnitude that they have been reduced by more than half in the last 20 years, with a saving to the industry of millions of dollars annually.

Until recently, the improvement in electrical sheet steel was confined largely to iron losses. Practically no improvement in permeability had been accomplished. As a result of recent research and development we now have a magnetic steel that has not only lower iron loss but also much better permeability.

New alloys are sometimes discovered and developed as by-products of other research work. In the electrical industry, the need for new alloys with special characteristics often arises in connection with new electrical developments. It is, therefore, often necessary to develop special alloys to meet limitations encountered in electrical developments, particularly when the volume required is too small to be attractive to alloy manufacturers. For example, a recently developed alloy containing only a few per cent iron, is stronger at 1,100 degrees Fahrenheit than any low-carbon steel at room temperature. It creeps very little. It survives a 6,000-hour creep test at 1,000 degrees Fahrenheit that causes cast carbon-molybdenum steel to fail and high-strength nickel-chromium steel to creep 100 times as much.

Chemistry

The application of chemistry to the electrical industry has been almost unlimited. Chemists have been called on principally to produce new and improved insulating materials, compounds, varnishes, oils, etc. There have been many other developments, however. For example, a fireproof chlorinated compound has been developed to replace transformer oil in applications where fire hazards exist.

Physics

The foundation of the electrical industry is supported to a large extent on the laws of physics. Some of the most important scientific discoveries and applications therefore have come from this field. The discovery of electro-magnetism, the electron, and the X ray are outstanding examples. From researches on the mechanics of the ion came the principle of circuit interruption by deionization that has been applied to a whole family of interrupting devices from the giant circuit breakers that handle millions of kilovolt-amperes down to the new practical circuit breakers for the homes that are little larger than a wall switch. In the field of electronics, numerous electrical developments of far-reaching importance have been based on these and similar discoveries.

Mathematics

Probably no other industry rests on such a precise mathematical basis

as the electrical industry. From its very beginning its every step in the design, construction, and operation of electrical apparatus has been guided by computation. In fact, the electrical engineer has invented several mathematical tools to serve his purposes, such as the complex quantity and symmetrical components. He has even placed his mathematics on a mechanical basis, such as that amazing creation, the calculating board.

Pure mathematical concepts have given birth to many electrical devices. Particularly has this been true of relays for the protection of transmission lines and terminal equipment.

As To The Future

We know so little about nature's basic underlying principles that it is incredible that anyone should think that our knowledge of natural laws is anything but exceedingly small when compared with the vast amount that is listed in the unknown column. This alone should be encouraging, for if we can accomplish all that we have with such a poor understanding, it is reasonable to expect vastly better results as we obtain more basic knowledge.

While our human limitations may prevent us from seeing very far into the future, present developments give us some idea of future trends and in what fields expansions are likely to occur.

Editor's Note:

(The author here refers to applications that have been made which point to further advancements that we may expect. These include the use of electricity for heat treatments, in air conditioning, in high frequency applications, in the field of electronics, in the home and on the farm. From the advances accomplished in lightning control, he has reason to believe that lightning will eventually be eliminated as a hazard to power continuity.)

Present researches in nuclear physics in many institutions may result in obtaining information that will be just as extensive in its influence on the development in the electrical industry as was the discovery of the electron. The production of radio-active substances, through the disintegration of the atom may provide a very useful tool. Naturally, one thinks of using these radiations instead of the X ray for radiography or for radium in the treatment of disease. While they no doubt will be used to some extent for such purposes, the possibility of using these radiations as a means of studying certain atomic reactions and structures may be even more useful. For instance, by the use of electrical detection methods, it appears feasible to follow the migration of radio-active atoms through a metal during heat-treating processes. Similarly, it is possible to trace the movement of radio-active substances through a plant or the human body and thus learn more about how and where these substances are assimilated. In contrast to radium, most of these artificial radio-active substances have such a short life that no permanent harm is done to the human system.

The present methods of generating

electric power are so well established that we are inclined to accept them as permanent. Gradual improvements in present methods have reduced the amount of coal used per kilowatt-hour to approximately one-fourth that required 20 years ago. While this improvement is indicative of real progress in steam power generation, it is still small when compared with the theoretically possible energy that could be gotten from a highly efficient method of energy conversion.

With an increasing knowledge of fundamental properties of matter and a better understanding of the conduction of electricity in gases, recent calculations and experimental work indicate that it may be possible to use the electromagnetic properties of the rapidly moving ionized products of combustion of certain fuels in conjunction with some suitable electrical transforming device as a means of generating electric energy. A practical development of this idea, which at least appears to be a possibility at the present time, would result in the use of static electrical devices extracting power from the kinetic energy of the gases of combustion without the intervention of rotating electrical machinery.

Although these and many other prospective developments that might be mentioned are indefinite and difficult to evaluate, we can look forward with the expectation that the electrical industry will continue to grow under the stimulation and impetus of new scientific discoveries and advances.—*Electrical Engineering.*

McVittie generating station, Sudbury District.

Power From Uranium

IN the August issue we reprinted a short article, "U-235", descriptive of the isolation of one of the isotopes of uranium, a material from which it may be possible to take "several million times the energy to be obtained from burning an equal weight of coal". Later we find in *Magazine Digest* a record of further progress that has been made in the study, written by Roy Davis, "Uranium—Fuel of the Future", from which we quote.

Toward the end of May Professor Wilhelm Krasny-Erger of the Wenner-Graens Institute of Stockholm, Sweden, informed the eager scientific world that he had succeeded in devising a relatively simple and inexpensive apparatus by means of which production of U-235 could be speeded up 11,000 times. By using his method it is now possible to produce one pound of Uranium-235 in four days or less, depending on the size of the plant.

Professor Erger's apparatus is amazingly simple. It consists of two tubes ten meters long, one having an outer diameter of four centimeters and set within the other. The two tubes are separated by a porcelain wall and the method used is described as the thermal-diffusion method of Clasius and Dickel or Brewer and Bramley.

Since the thermal-diffusion method works better with gases, Professor Erger sought a volatile compound of Uranium and found it in Uranium Fluoride—UF_6.

The outer tube, separated from the inner by a distance of 1.34 millimeters, is kept at a temperature of 60 degrees Centigrade, one degree above the freezing point of uranium fluoride. The temperature of the inner tube is 393 degrees Centigrade. With five grams of uranium fluoride placed in the outer tube, the time for the extraction of U-235 is set at 80 days. During this period of time the concentration of the metal is increased by 6.7 times.

But even with the apparatus designed by Professor Erger a single extractor needs 397,205 days or 1,088 years and 86 days to extract one pound of pure U-235. However, 1,000 such units require but 397 days; 10,000 units only 39.7 days; 100,000 units only 3.97 days. The apparatus can be produced for about $100 per unit. A plant of 100,000 extractors will thus cost only $10,000,000.

As to the extent to which we may expect to find U-235 produced and used for power generation and its effect on the present means of power generation, Mr. Davis makes the following statement.

The question arises whether there is enough uranium available in the earth's core to supply the energy needs of mankind for any length of time. Here we must differ from a number of publica-

tions which wrote during the past two months that uranium is found dispersed throughout the world. Actually, commercially profitable sources of uranium are not widespread ("Encyclopaedia Britannica") and generally consists of rare minerals.

Moreover, uranium is always found in combination with other metals and minerals. Radium and helium are invariably present. Pitchblende, also called uraninite, greatest source of the metal, also contains silica, thoria, rare earths, lead, iron, calcium, manganese, magnesium, bismuth, etc. Indeed pitchblende contains from 75 to 85 per cent. of U_2O_3 from which the metal in pure form may be obtained. The richest known deposits of pitchblende are found in Canada at Great Bear Lake in the Northwest Territories. The next most abundant source is at Katanga in the Belgian Congo. Carnotite, found in Colorado and Utah, contains only 3 per cent. of uranium oxide. Other uranium-bearing minerals such as gummite, uranosphaerite torbenite, uranite, etc. are found in Saxony, Cornwall, Russia, Sweden, Norway, South Australia and Portugal. The most important European deposits are at St. Joachimsthal, Czechoslovakia. Since the Katanga deposits contain only from 25 to 36 per cent. uranium oxide, Canada and particularly the Great Bear Lake area appears to be destined to become the future center of the world's supply of the new energy.

Although definite information on the world production of uranium is lacking, each firm jealously guarding its own figures, the yearly total is estimated at nearly 2,000,000 pounds of U_3O_8, of which 85 per cent. or 1,700,000 lbs. is pure uranium. Since the ratio of U-235 to ordinary uranium is as one to 139, the world production of the 1,700,000 pounds of the pure metal contains the total of 12,230 lbs. of U-235 or the equivalent of energy contained in 61,150,000,000 lbs., or 30,575,000 tons of anthracite. Were all the presently-available uranium converted to the extraction of U-235, the total energy-result would still remain below two-thirds of the yearly anthracite production in the United States. To substitute the yearly total of coal used in the United States, 156,000 pounds of pure U-235 would be needed for the extraction of which 24,684,000 pounds of pure uranium would be necessary. This would amount to fifteen-fold the present world production of the metal. However, it is expected that U-235 will be mainly utilized in engines requiring high sources of energy with little weight, such as in airplanes, steamships, trains and submarines.

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The BULLETIN

The Hydro-Electric Power Commission of Ontario

Volume XXVIII **JANUARY, 1941** **Number 1**

Chats Falls on the Ottawa River before development

Municipal Loads, December, 1940

NIAGARA SYSTEM

25-Cycle

	H.P.	Population
Acton	1,240	1,869
Agincourt	202	P.V.
Ailsa Craig	136	483
Alvinston	117	650
Amherstburg	937	2,857
Ancaster Twp.	411	V.A.
Arkona	61	397
Aurora	1,176	2,770
Aylmer	848	2,156
Ayr	244	730
Baden	335	P.V.
Beachville	568	P.V.
Belle River	180	814
Blenheim	624	1,758
Blyth	144	656
Bolton	201	600
Bothwell	157	694
Brampton	2,832	5,695
Brantford Twp.	1,012	V.A.
Bridgeport	127	P.V.
Brigden	90	P.V.
Brussels	163	773
Burford	194	P.V.
Burgessville	41	P.V.
Caledonia	424	1,425
Campbellville	50	P.V.
Cayuga	156	682
Chatham	7,447	16,517
Chippawa	342	1,140
Clifford	104	452
Clinton	619	1,888
Comber	121	P.V.
Cottam	91	P.V.
Courtright	44	329
Dashwood	99	P.V.
Delaware	78	P.V.
Delhi	755	2,083
Dorchester	116	P.V.
Drayton	144	527
Dresden	458	1,572
Drumbo	102	P.V.
Dublin	65	P.V.
Dundas	2,306	4,837
Dunnville	1,342	3,928
Dutton	275	793
Elmira	797	2,074
Elora	387	1,149
Embro	113	423
Erieau	86	295
Erie Beach	10	28
Essex	546	1,854
Etobicoke Twp.	7,315	V.A.
Exeter	606	1,649
Fergus	1,192	2,792
Fonthill	191	867

	H.P.	Population
Forest	521	1,520
Forest Hill	7,748	11,117
Galt	9,578	14,219
Georgetown	1,628	2,345
Glencoe	240	726
Goderich	1,581	4,407
Granton	65	P.V.
Guelph	10,853	21,514
Hagersville	547	1,355
Harriston	385	1,269
Harrow	469	1,032
Hensall	245	685
Hespeler	2,712	2,789
Highgate	92	362
Humberstone	496	2,738
Ingersoll	2,728	5,177
Jarvis	231	519
Kingsville	767	2,359
Kitchener	24,811	33,080
Lambeth	150	P.V.
LaSalle	212	882
Leamington	1,764	5,630
Listowel	1,296	2,773
London	41,311	77,369
London Twp.	630	V.A.
Long Branch	1,114	4,140
Lucan	205	610
Lynden	124	P.V.
Markham	387	1,153
Merlin	125	P.V.
Merritton	7,314	2,656
Milton	1,230	1,848
Milverton	357	1,010
Mimico	2,686	7,012
Mitchell	706	1,615
Moorefield	39	P.V.
Mount Brydges	110	P.V.
Newbury	43	288
New Hamburg	632	1,458
Newmarket	1,657	3,495
New Toronto	10,437	7,140
Niagara Falls	11,686	18,928
Niagara-on-the-Lake	728	1,670
Norwich	423	1,365
Oil Springs	219	514
Otterville	122	P.V.
Palmerston	591	1,406
Paris	1,751	4,427
Parkhill	211	900
Petrolia	1,183	2,747
Plattsville	95	P.V.
Point Edward	1,492	1,177
Port Colborne	2,231	6,503
Port Credit	820	1,901
Port Dalhousie	708	1,590
Port Dover	442	1,705

	H.P.	Population
Port Rowan	105	556
Port Stanley	298	737
Preston	3,357	6,422
Princeton	111	P.V.
Queenston	130	P.V.
Richmond Hill	463	1,317
Ridgetown	658	1,958
Riverside	1,226	5,090
Rockwood	110	P.V.
Rodney	196	695
St. Clair Beach	74	106
St. George	151	P.V.
St. Jacobs	195	P.V.
St. Marys	1,490	4,033
St. Thomas	7,934	16,352
Sarnia	10,244	18,269
Scarborough Twp.	4,224	V.A.
Seaforth	635	1,705
Simcoe	2,675	6,052
Smithville	157	P.V.
Springfield	70	377
Stamford Twp.	2,474	8,047
Stouffville	280	1,160
Stratford	6,941	17,159
Strathroy	1,312	2,917
Streetsville	183	700
Sutton	190	852
Swansea	3,275	5,831
Tavistock	628	1,063
Tecumseh	311	2,237
Thamesford	204	P.V.
Thamesville	250	833
Thedford	116	595
Thorndale	56	P.V.
Thorold	2,675	5,001
Tilbury	776	1,980
Tillsonburg	1,457	4,376
Toronto	379,542	647,803
Toronto Twp.	2,669	V.A.
Wallaceburg	2,751	4,715
Wardsville	45	236
Waterdown	214	904
Waterford	478	1,216
Waterloo	4,532	8,524
Watford	378	964
Welland	10,984	11,072
Wellesley	135	P.V.
West Lorne	151	837
Weston	4,260	5,289
Wheatley	194	760
Windsor	48,462	103,813
Woodbridge	611	830
Woodstock	7,989	11,418
Wyoming	94	516
York E. Twp.	8,352	37,829
York N. Twp.	6,669	V.A.
Zurich	117	P.V.

THE BULLETIN

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Most Active Year in Hydro History

By Dr. T. H. Hogg, Chairman and Chief Engineer, The Hydro-Electric Power Commission of Ontario

THE past year's work of The Hydro-Electric Power Commission of Ontario has, of course, been dominated in every department by the necessity for co-ordinating activities to the war effort of Ontario and of the Dominion.

The beginning of the fiscal year, in November, 1939, found the Commission in a favourable position with respect to power supplies, and the promise then made that Hydro could, during 1940, meet a greatly increased demand for power for industries manufacturing munitions and war supplies has been satisfactorily kept without undue difficulty.

Meanwhile the successful resistance offered to the enemy by Britain following the collapse of France has given Canada time to adjust its war programme and greatly accelerate the pace of its war preparations. For the war industries additional power in large amounts has been required and utilized, and this increased industrial activity directly associated with the war has stimulated increased demands for power for commercial, domestic and rural service. During the past year all of these extra demands were satisfactorily met and attention was directed to the best means of ensuring ample supplies of power for the future.

Canada's ability to contribute to the Empire's cause should greatly exceed that of any other nation with an equal population. This is due to its great natural resources and to the up-to-date character of its equipment for making the most speedy and effective use of these resources.

Perhaps the most important item of Canada's modern equipment is its low-cost hydro-electric power—available in ample supplies in practically all provinces. It is, for example, of immense importance to Canada's war effort that in the areas where its in-

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Vol. XXVIII No. 1

January, 1941

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

dustrial plants are most thickly established—Ontario, Quebec, and to a lesser degree in British Columbia and Manitoba—there have been developed large hydro-electric power resources, and that electric power is distributed to industries at prices that encourage its generous use.

One of the ways in which the developed water powers of Canada are being put to use in connection with war activities is in the production of non-ferrous metals and other minerals. Thus, in British Columbia a large amount of power is employed in mining and refining zinc, lead and copper. In Quebec, large blocks of power from water powers situated near tidewater have been put to good use in developing a large aluminum industry utilizing bauxite ore imported from British sources. Similarly, in Ontario large quantities of hydro-electric power are used in mining and refining copper and nickel as well as in the production of gold. Other minerals being produced in useful quantities in Canada for war purposes include asbestos, mica and magnesite in Quebec, and platinum, cobalt and mica in Ontario.

Increased demand for power for war industries is inevitably accompanied by an increased tempo in nearly all activities. It is therefore true, as has been pointed out, that Canada cannot play the full part that is being assigned to her and that she is willingly accepting, unless there can be made available large additional quantities of power. If these are to be provided from waterpower developments, plans must be made well in advance.

Continuous attention is therefore being paid by the Commission to the problem of ensuring that the power resources of Ontario shall be ample to service all war demands. During the past year, to meet the growing demands for power, the Commission advanced the date of taking 20,000 horsepower from the Maclaren-Quebec Power Company from November 1st to July. Other possibilities of increasing its power supplies have and are being examined.

Ogoki River and Long Lake Diversions

One of the most important actions taken during the past year for increasing Ontario's power supplies was the arrangement made for diverting water from the upper reaches of the Ogoki and Kenogami rivers to lake Superior — projects known as the Ogoki and Long Lake diversions. The value of these diversions at the present time rests directly upon the co-operation extended by the United States to the Dominion of Canada. The friendly co-operation of our neighbours to the south has resulted in an understanding whereby Canada is enabled to utilize immediately for the increase of power output at Niagara for war purposes an additional flow of water equivalent to that which will be added to the Great Lakes when the diversion works are completed, Canada undertaking to put in hand at once the construction of the necessary dams, channels, etc., for the Ogoki diversion and to divert to lake Superior immediately the 1,000 cubic feet of water per second from Long lake, for which the physical works have already been completed.

Under the stimulation of war activities, not only does increased industrial activity produce an increased demand for additional horsepower at certain times of the day, but it also increases the continuous demand for electric energy at all times. For both purposes the ability to put to use an additional water flow of 5,000 cubic feet per second through the power plants on the Niagara river is of special and immediate value.

St. Lawrence River Project

Although the diversions into the Great Lakes from Northern Ontario have been dealt with on the basis of a friendly understanding with the United States, they have, of course, a bearing upon the much larger considerations relating to the improvement of the St. Lawrence river for navigation and for power. This subject is again prominently before the people of eastern Canada and in connection with future power resources of Ontario is of basic importance. The St. Lawrence river improvement is undoubtedly an enterprise that will profoundly influence the growth and progress, not only of Ontario and Quebec, but of the whole of Canada. As a project it is now linked up with the steps being taken jointly by the United States and Canada for the defence of the Americas. It is evident that changing world conditions must profoundly modify many of the views previously held respecting this great undertaking. During the past year certain investigations and studies relating to power development on the international section of the river were carried on by the Commission.

Improved Equipment

Before the war started the Commission planned and in part carried out a general strengthening of its transmission lines and distribution networks. These improvements enable the Commission to transfer power with greater facility from one part of the province to another; the Commission also constructed one additional power development at Ragged Rapids to serve the Georgian Bay system. Since the war started fur-

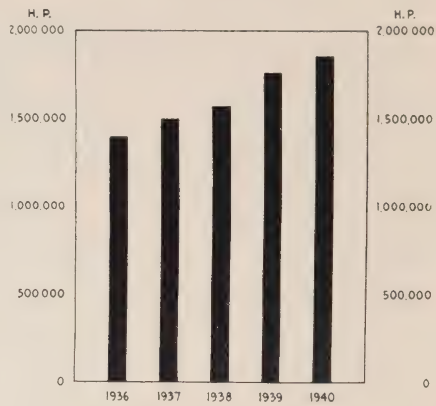
ther and continuous improvements have been made to the transmission networks and at the present time two additional power developments are under construction.

GROWTH IN LOAD

The upward trend in load which featured the closing months of the Commission's fiscal year of 1939 continued throughout the whole of the fiscal year which ended October 31st, 1940. For eleven months up to September the average increase in monthly peak load was about 14 per cent, or slightly more than 200,000 horsepower. In October the comparison with a year ago was affected by the extension of Daylight Saving Time in many municipalities. It is not possible to evaluate with exactness the effect of this extension of Daylight Saving Time, however the load in October 1940 did not continue the same peak load increases. In October 1939 the primary load of all systems combined was 1,669,337 horsepower and rose to 1,783,962 horsepower in October of the current year, an increase of 6.9 per cent, or approximately 115,000 horsepower. The reduction in peak demand above noted cannot be taken as representing the true saving attributable to the extension of Daylight Saving Time. Taking into consideration the various factors involved, it is estimated that the saving attributable to this cause will this winter be from 65,000 to 85,000 horsepower.

The greater portion of the year's primary load increase was centred in the Niagara system which absorbed about 150,000 horsepower of the 200,000 horsepower increase in load;

TOTAL PRIMARY PEAK LOADS
ALL SYSTEMS



and about one-third of the Niagara system primary load increase can be traced to war-time production in the electro - metallurgical and electro-chemical industries along the Niagara river.

Substantial increases in load, in large part due to the production of war material, were also recorded in both the Georgian Bay and Eastern Ontario systems. The load of the Thunder Bay system, however, due to lighter demands by the grain elevators, showed but little growth over the previous year.

In Northern Ontario the phenomenal load growth, which has been experienced now for several years in connection with the mining fields, continued its upward trend. The total primary load in the districts served by the Northern Ontario Properties rose from 168,000 to 202,000 horsepower, an increase of some 20 per cent.

The total consumption of energy in all systems for primary purposes was 7,838,000,000 kilowatt-hours, being no

DISTRIBUTION OF PRIMARY POWER TO SYSTEMS
20-Minute Peak in Horsepower—System Coincident Primary Peaks

SYSTEM	Load in Horsepower October 1939	October 1940
Niagara system—25-Cycle	1,171,582	1,237,802
" " —D.P. & T. division	56,970	50,134
Georgian Bay system	34,756	42,217
Eastern Ontario system	141,908	154,207
Thunder Bay system	96,160	97,855
Manitoulin rural power district	273	330
Northern Ontario Properties		
Nipissing district	5,188	5,121
Sudbury district	19,740	17,208
Abitibi district	130,968	164,879
Patricia-St. Joseph district	11,792	14,209
Total	1,669,337	1,783,962

less than 19 per cent in excess of the corresponding consumption of energy in the previous year. This higher increase in energy as compared with the increase in peak demand reflects longer hours of use in war-time production.

In addition to meeting all primary demands, the Commission utilized its reserve capacity to produce an additional 1,849,000,000 kilowatt-hours for secondary power purposes during the year.

ADDITIONS TO GENERATING, TRANSMISSION AND DISTRIBUTION EQUIPMENT

During the year the addition of unit No. 3 was completed at the Ear Falls development in the Patricia-St. Joseph district, and work was commenced on the Big Eddy development to serve the Georgian Bay system, and the Barrett Chute development to serve the Eastern Ontario system.

The extension to the Ear Falls development was completed in June, 1940. It involved the construction of concrete pipe lines, powerhouse substructure, excavation of tailrace and the installation of hydraulic and electrical equipment. The unit has a rated capacity of 7,500 horsepower, under a head of 36 feet. The total installed capacity of this development is now 17,500 horsepower, comprising two 5,000 horsepower units with fixed blade propeller turbines and one 7,500 horsepower unit with adjustable blade turbine.

The Big Eddy development on the Musquash river is situated about nine miles below Bala and four miles below the Ragged Rapids generating station which was brought into service in 1938. It will have a turbine capacity of 10,000 horsepower under a head of 36 feet and will contain two units. It is expected to come into operation in November, 1941.

The Barrett Chute development, situated on the Madawaska river about five miles above Calabogie vil-

lage, will contain two units with a total rated capacity of 56,000 horsepower under a head of 154 feet. The Commission is also constructing a storage dam at the outlet of Bark lake about 67 miles upstream from Barrett Chute. Both the development and the storage works are expected to be available for service in 1942.

In July 1940 the new 110,000-volt single-circuit line on steel towers between St. Thomas and Windsor was placed in service. This line, which has a capacity equal to the other two existing lines on double-circuit towers, has greatly improved operating conditions of the western section.

In the eastern section of the province substantial progress was made on the construction of a new 220,000-volt line which, when completed, will extend from the eastern boundary of the province, the Quebec border, to a new transformer station being constructed at Burlington. To date about 150 miles of towers and footings have been erected and 75 miles of wires have been strung. The receiving transformer station is being designed for an ultimate capacity of 450,000 kv-a. The initial installation will be two banks of three 25,000 kv-a. single-phase transformers, together with regulators, oil circuit-breakers and other equipment. Other activities in connection with the Niagara system include the completion of three large transformer stations at Toronto, Thorold and near Simcoe. Another transformer station is under construction at Hamilton and additional transformer capacity has been installed at many other stations in the Niagara systems.

In the Georgian Bay system a frequency-changer station was installed at Hanover as an additional tie for the exchange of power between the Niagara and Georgian Bay systems. In the Eastern Ontario system the capacity of the Ottawa transformer station was increased by the installation of an additional bank of three 5,000 kv-a. transformers.

Distribution an Important Factor

The multiplicity of demands for increased supplies of electricity throughout the province sets in motion a cycle of events which is not completed until the customers' demands are actually satisfied. Not only must transmission lines and transformer stations be constructed for the wholesale delivery of the power, but throughout the length and breadth of the land secondary transformer stations must be built or enlarged and new distribution lines must be built, or existing lines be increased to greater capacity. Even the installation of equipment in the larger consumers' receiving stations must be supervised.

The consequence of this heavy demand for additional electric service during the past year has been an amount of engineering and administrative work that is unprecendented in the Commission's history. Many of the new distributing stations and additions to existing stations have been provided for the specific purpose of supplying power to industries engaged on war supplies. In this connection the aim of the Commission has been to anticipate, where possible, the demands for Hydro service for war purposes.

In the north country constructional activities have proportionately been even greater than in Southern Ontario. Over 43 miles of transmission circuits were erected for the Northern Ontario Properties; many improvements were made to distributing networks, and additional capacity added to many transformer stations.

In rural Ontario the construction of about 1,400 miles of rural primary line was authorized during the year to serve applications from some 10,000 new rural customers.

MUNICIPAL HYDRO UTILITIES

The activities of the Commission reflect in large measure the electrical service requirements of the local Hydro and public utility commissions. During the past year reports from the co-operating municipalities show that load increases attributable to war activities have been widespread. Many of the larger demands from new chemical and metallurgical works, armament and steel plants have been served by the Commission as system customers and most of the air training fields are served by the Commission through its rural power district lines. But municipal Hydro utilities have given Hydro service to war industries including air-craft and aircraft parts factories, and to other plants being extended or changed for the production of shells and ammunition.

In addition, the production of a large number of smaller factories has been stimulated by conditions arising out of the war. This general and widespread increase in municipal demands has necessitated revisions and extensions to the distribution networks-betterments which, it is hoped, will serve many new industries that may become permanently established in Ontario.

SATISFACTORY FINANCIAL PROGRESS

The full financial record of operations of the past year is not yet available, but it may be stated, that notwithstanding the maintenance of low rates for Hydro service, there has been a satisfactory increase in revenue. Full customary reserves for renewals and sinking fund have been provided and there will remain a substantial balance to be set aside as reserves for contingencies and for stabilization of rates. Capital expenditures approximating eleven and one-half millions of dollars are somewhat above the normal increase, but on account of the exceptional demands for war purposes, many new transmission lines and stations have to be constructed.

RESEARCH WORK

Since the last war an important contribution to the growth and progress of this Dominion as a scientific and industrial state has been made by research workers. Fortunately Canada has been farsighted in supporting this fundamental aid to industrial progress.

The Testing and Research Laboratory of the Commission is giving valuable technical assistance to the Department of Munitions and Supply and to the United Kingdom Technical Commission in connection with electrical matters.

REGULATIONS BY DOMINION POWER CONTROLLER

While it is not anticipated that the necessity will arise in acute form, as it did in the last war, nevertheless

there are certain economies in consumption that can be effected if found necessary. Great care, however, must be exercised in determining when and how to impose such restrictions. It is quite possible to secure a saving of electricity at the cost of imposing other burdens which would diminish rather than increase Canada's total war effort.

In order to ensure that all available developed power resources shall be used to a maximum advantage in connection with Canada's war effort, a Power Controller with wide powers has been appointed by the Dominion Government. The Hydro Commission is co-operating with this Dominion official and has, moreover, been given wide powers of a similar character under "The Power Control Act, 1939" of Ontario.

It is not at present necessary to ration primary power for industrial purposes, nor indeed to restrict its use in any way. Now that this winter's peak demand is past, it is unlikely that any necessity for rationing will arise until next winter, if then. In any case it is not a job that can be done by the individual; the man in the street cannot prescribe remedies for power shortage. Regulations will be made when and if it becomes necessary by the Power Controller, the Hydro Commission, or the local electric utility, under the direction of these supervising authorities.

Since the extension of Daylight Saving Time in Ontario and Quebec by order of the Dominion Power Controller, there have been various suggestions made in the press that electric power could be conserved by cutting off street and highway lighting and electric signs, and some people have gone to the length of trying to conserve electricity in their homes. Such efforts, while being commendable because they are sincere, are not very helpful. For the time being it is recommended that everybody should continue to use electricity as fully as needed until they receive advice from the Power Controller or from their local electric utility, otherwise they may interfere with their own war effort.

Efficient Utilization of Hydro Service

The Commission's programme of Sales Promotion was planned for the past year to meet the changed conditions imposed by the War. Due to Ontario's position as the major industrial province of Canada, industrial and lighting requirements received chief attention, and stress was laid on assisting industry to use electrical energy in the most efficient manner. This service has been welcomed, and used to excellent advantage by many industrial organizations throughout the province.

While increasing attention was given to this industrial work, domestic and rural problems were not overlooked. In the rural areas, in particular, every effort was made to foster the use of electricity on the farm in ways that would enable the farmer to produce in greater volume at lower cost.

Still Ample Supplies of Power

There is now available in Canada more than four times the amount of electrical power that was available

in 1918 at the close of the last war. Because the front line now runs through the factories, the importance of ample power supplies can hardly be over-estimated. This fact is of great significance, but it must be appreciated that great growth in the development and utilization of electric power has also taken place since the last war in European countries now dominated by the enemy. It is a big task to reorganize our productive capacity and to divert our material and mechanical resources into the channels of war production in an effective way. But so far as power production and supply is concerned, it is believed that Ontario, and Canada generally, can move forward with confidence.

Commission War Savings Plan

IN co-operation with the Dominion Government in furthering the sale of War Savings Certificates, the Hydro-Electric Power Commission of Ontario has adopted the Payroll Deduction Plan to enable its employees to purchase them. The plan was introduced to each member of the staff by the following letter from the Chairman:

To Hydro Employees:

The War Savings Committee at Ottawa, in an urgent appeal to all employees to increase the purchase of War Savings Certificates through the Payroll Deduction Plan, points out that more than $10,000,000 per month is required by sale of these certificates to meet the requirements of your Government for war purposes.

To maintain our active service forces, and provide the necessary training fields, munitions and equipment, one billion dollars per year is needed. Of this amount, only $150,000,000 need be raised by sale of War Savings Certificates, as compared with $850,000,000 to be secured from other sources. At the moment, about $30,000,000 per year is secured by the sale of certificates. Therefore, the urgency for increased support of this saving plan.

Response to this appeal will avert the possibility of compulsory measures. War Savings Certificates are the safest *investment* obtainable. For every $4 you invest, you will receive $5 in return. Furthermore, do not forget that this money will be repaid in Canada, and will be spent in Canada, to produce Canadian business and Canadian wages.

The British Empire is engaged in a desperate struggle against a ruthless enemy. In enemy countries, sacrifice is imposed by law, and in invaded countries, all of value has been seized. Our voluntary sacrifice is essential, if we would avoid a similar fate. Our soldiers, sailors and airmen offer their lives to protect us, while we are asked to *lend* our savings. It is unthinkable that we, who are in comparative safety, should fail them.

The Commission is co-operating in this Payroll Deduction Plan. While the purchase of Certificates is in no way compulsory, nevertheless, it is our hope that every employee will consider it a duty of citizenship to co-operate. Bear in mind that you are not asked to give your money, but only to lend it to your country.

Yours sincerely,
(Sgd.) T. H. HOGG,
Chairman.

The response to the request in Dr. Hogg's letter has been most gratifying. The results so far indicate that the employees of the Commission will agree to monthly salary investments in War Savings Certificates which will amount to at least $25,000 per month.

We understand that the employees of many of the local commissions are to adopt the same plan of monthly investments of part of monthly salaries in War Savings Certificates.

Sir Robert Hadfield, Bt., F.R.S.

WE HAVE to record with regret the death in September, 1940, of Sir Robert Hadfield, the Chairman and Managing Director of Messrs. Hadfields, Ltd., and a Vice-President of The British Electrical and Allied Manufacturers' Association. He was 81 years of age.

The firm of Hadfields, Ltd., first known under the name of Hadfields Steel Foundry Co., was founded in 1872 by his father, Robert Hadfield, who died in 1888. Upon the death of the founder, the firm was formed into a limited company of which Sir Robert had been Chairman and Managing Director for twenty-nine years—a noteworthy record in industrial administration.

Born in 1858, Robert Abbott Hadfield was educated at the Sheffield Collegiate School, where he was successful in taking a number of prizes and scholarships. When only 20 years of age he founded and inaugurated the chemical and physical laboratories of his father's works at Attercliffe. Here began the eventful scientific life which was to make him world-famous as a metallurgist.

In the course of his career Sir Robert received practically every medal of the first significance which can be awarded by the steel and metallurgical associations in Great Britain, America, and the Continent. He was the inventor of manganese steel, for the discovery of which the Institution of Civil Engineers conferred upon him the Telford Gold Medal in 1888. In 1899 he was elected Master Cutler of that ancient Cutlers' Company of Hallamshire, Sheffield, dating from 1624, at the Feast of which he had as his chief guest the late Lord Lansdowne. In the same year the Institution of Civil Engineers presented him with the George Stephenson Gold Medal for

research in nickel-iron alloys. In 1902, a year of great advance in Sheffield, the Institution of Civil Engineers bestowed upon him the Howard Quinquennial Prize for scientific work in connection with new alloys of Steel. Former recipients of this prize were Sir Henry Bessemer and Sir William Siemens.

In 1904 he was awarded the Bessemer Gold Medal by the Iron and Steel Institute and the following year was elected President of that body. The visit of the Institute to Sheffield in the first year of his presidency was regarded by him as a marked incident in his life. He was knighted in 1908.

Sir Robert became a Fellow of the Royal Society in 1909. In 1911 the University of Sheffield conferred the honorary degree of Doctor of Metallurgy upon him, and in the following year he received the honorary degree of Doctor of Science from the University of Leeds. He was elected President of the Faraday Society in 1914, and held the office in succeeding years with distinction until 1920.

Sir Robert was created a baronet in 1917. In 1925 he was made an "Officer" of the Legion of Honour and Commander in 1937. He was elected a Member of the French Academy of Sciences in 1923, also an Honorary Member of the French Society of Industrial Chemistry. He also held the John Fritz Gold Medal, bestowed in 1921, the highest prize of the kind that America can offer. A further distinction was the election of Sir Robert as Foreign Associate of the Washington National Academy of Sciences in 1928. The University of Oxford bestowed upon him the honorary degree of Doctor of Science, and the Council of the Institution of Mechanical Engineers elected him an Honorary Life Member. Sir Robert Hadfield had been a Vice-President of The British Electrical and Allied Manufacturers' Association since 1923.

He has written some 300 scientific papers and addresses. He is also the author of two books which are almost classics, *Metallurgy and Its Influence on Modern Progress* and *Faraday and His Metallurgical Researches*.—*BEAMA Journal.*

Ear Falls development, Lac Seul.

Joints in Steel Reinforced Aluminum Conductor

Tested in place for alignment of Steel and Aluminum Sleeves

By J. E. Reid, Transmission Section, Electrical Engineering Department, H.E.P.C. of Ontario

JOINTS in steel reinforced aluminum cable are made by using two sleeves, one over the steel core and the other for the aluminum conductor and the steel splice (Fig. 1). In making the joint the core of each conductor is bared for about five inches, the ends are inserted in the steel sleeve, and the steel compressed by cold flow of the material in a hydraulic press. The aluminum sleeve, previously put on one conductor, is centred over the steel sleeve and compressed. In this final operation the steel sleeve is so covered by the aluminum sleeve that it is possible for the steel sleeve to be considerably displaced towards either end of the aluminum splice or joint. Joints have come apart due to poor alignment of the steel sleeve inside the aluminum sleeve. Several testing equipments have been devised to record electrically or magnetically just where the ends of the steel sleeve are in relation to the exposed ends of the aluminum sleeve.

Of these probably the simplest is that of winding an insulated coil of fine wire around the aluminum sleeve in the vicinity of the end of the steel sleeve. Pass a direct current through this coil and explore the magnetic effects with a compass needle as described in *Engineering Journal,* June, 39, Vol. 22, P 261. Where it is desirable to do this work with the conductor in place, it would take some time to send a man out in a cradle to wind the fairly long coil of wire. One magnetic type of testing apparatus, designed to determine the amount of misalignment within a splice of a de-energized conductor in place is herein described.

The apparatus (Fig. 2) consists of four similar coils mounted on an aluminum frame. Coils A and B are mounted on a laminated magnetic core (C), coils A^1 and B^1 on a similar core (C^1). The apparatus may be applied to the joint in two ways. If the joints are not more than thirty-five feet from ground, poles may be used to raise the apparatus which is then readily hooked over the conductor. For higher joints a trolley may be used to carry the apparatus from a tower to the joint. When the trolley is properly centred over the joint, the magnetic equipment, which is suspended above the conductor by springs, is pulled down to the top of the joint by a rope manipulated from the ground. In either case the apparatus, which is symmetrical, must first be properly centred over the aluminum sleeve. The ends of the lamin-

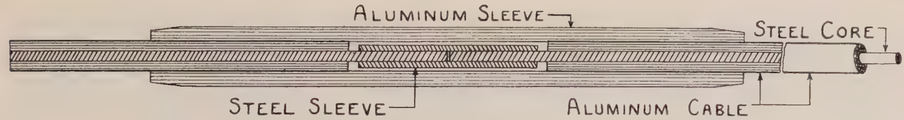


Fig. 1—Compression joint.

ated cores C and C' should not touch the aluminum sleeve. Carefully made "V" guides or hooks are necessary so that the apparatus is parallel to the joint.

Coils A and A' are connected to a battery on the ground. In the field six light radio 45 volt B batteries were found convenient. When the Key K is closed the current in A and A' causes magnetic flux in two magnetic circuits. One magnetic circuit is composed of the laminated core associated with coils A and B together with the steel core of the cable and part of the steel sleeve. The second magnetic circuit is similar at the other end of the joint, there being a considerable air gap in both magnetic circuits. If the steel sleeve is properly centred longitudinally in the aluminum sleeve, both magnetic circuits are the same, and the magnetic flux linking coils B and B' is the same. When the Key K is opened the decay of this flux causes equal voltages in B and B', which are so connected that these voltages cancel, producing no deflection on the galvanometer on the ground. If the steel joint in Fig. 2 is displaced to the left of centre, the flux linking coil B will be increased and that linking B' will be decreased, due to respective increases and decreases in the amount of steel in the magnetic circuits. When the Key K is opened the voltages induced in B and B' are no longer equal, hence do not

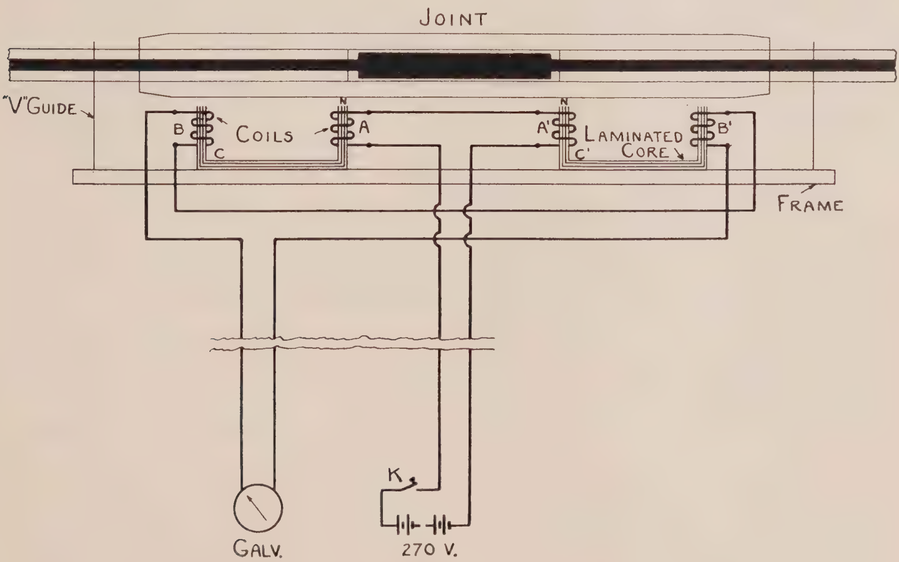


Fig. 2—Electromagnetic diagram of equipment.

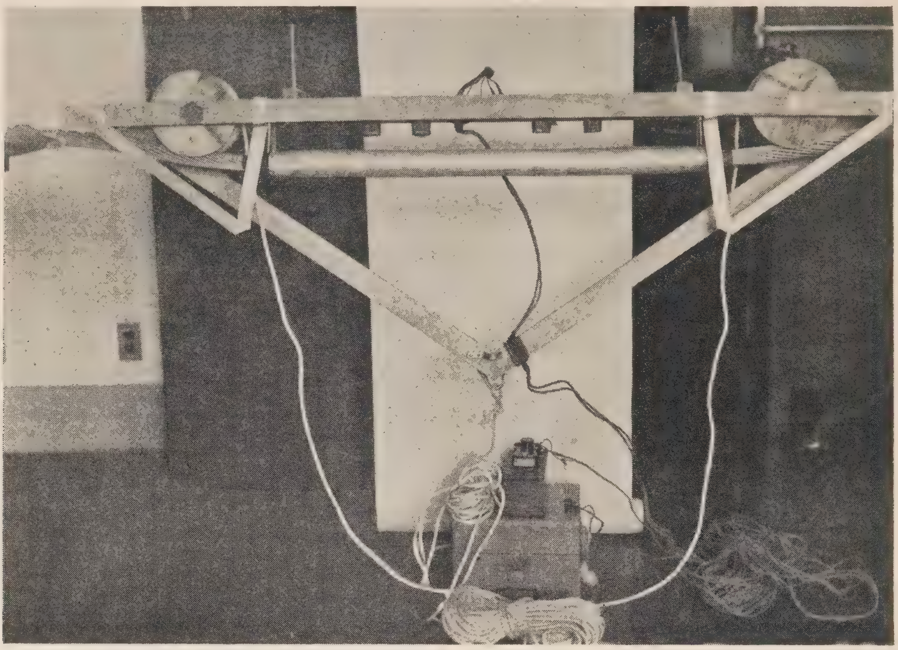


Fig. 3—Magnetic coils in position, with recording equipment and a wooden trolley. Magnetic coils in practice are usually much closer to the aluminum.

cancel completely and the galvanometer deflects momentarily in one direction. If the joint were misplaced to the right the galvanometer would deflect in the other direction.

After the apparatus is properly centred, very little time is necessary to test the joint. The galvanometer is actually used as a ballistic galvanometer, the maximum throw or swing of the needle being a measure of the amount of misalignment of the joint. Either the deflection obtained on closing or opening of the Key K may be used, that on opening being considered preferable. The instrument may be calibrated by making up a standard joint using the same conductor and steel sleeve. The aluminum sleeve is not necessary. The instrument is then applied to this joint and shifted known amounts each way from centre. Readings of the galvanometer at these positions give the information necessary for plotting a calibration curve. An error of alignment of one-half inch may be easily determined. A warped joint may account for an error in the reading of about one-half inch. Eddy currents induced in the aluminum cable and sleeve do not affect the readings of the galvanometer. The apparatus serves as an incidental check on the increase in length of the compressed joint, thus checking the correct operation of the hydraulic press and dies.

Drying with Infra-Red Radiation

By H. F. Davidson, Phometric Laboratory, H.E.P.C. of Ontario

CONSIDERABLE interest has been aroused in the last year or two by the application of infra-red radiation to various industrial processes, such as paint baking, dehydration and preheating. Radiant heating for industrial processes is comparatively new and there is a lack of complete information relating to its application, method of operation, and its limitations. Where the quantity of heat required is not too great, it has several advantages over other methods of heating, the most important of which is the reduction in drying time allowing increased production with no increase in space and at reasonable cost. In the following, an attempt will be made to explain the general methods of application of radiant heating, sources of infra-red, auxiliary equipment, and its application to paint baking and dehydration processes.

Nature of Infra-Red Radiation

Infra-red radiation, more commonly known as radiant heat, is contained in the portion of the spectrum just beyond and of longer wave-lengths than the visible red radiation. The visible portion of the spectrum extends from violet at about 0.4 microns wave-length (1 micron is one thousandth part of a millimeter) to red at about 0.70 microns, while infra-red radiation extends from 0.70 microns to wave-lengths of the order of magnitude of 100 microns. Heated bodies radiate energy and the amount of this energy emitted at the different wave-lengths depends on the temperature of the body. A steam radiator emits infra-red radiation of very long wave-lengths, while an incandescent body emits radiation of shorter wave-lengths, including both visible and infra-red. The distribution of energy radiated from a tungsten filament heating lamp operating at 2,500 deg. K* is shown in Fig. 1. Note that the peak in the curve occurs at about 1.15 microns. Radiation at this wave length has been found very satisfactory for the general run of radiant heating applications. As the temperature is increased, the peak shifts towards the visible region, i.e., the wave length of maximum radiation becomes shorter.

General Methods Employed

Heat can be transferred from one body to another by conduction, convection or radiation. The transfer of heat between different parts of the same body or between different bodies in contact is called conduction. Convection is the term applied when heat is transferred by the motion of heated

*The color or "degree of whiteness" of the light from an incandescent lamp is expressed by the color temperature of the filament in degrees Kelvin. When a drying lamp is said to have a color temperature of 2500 deg. K., it indicates the temperature at which a standard black body radiator must operate to produce light of the same color.

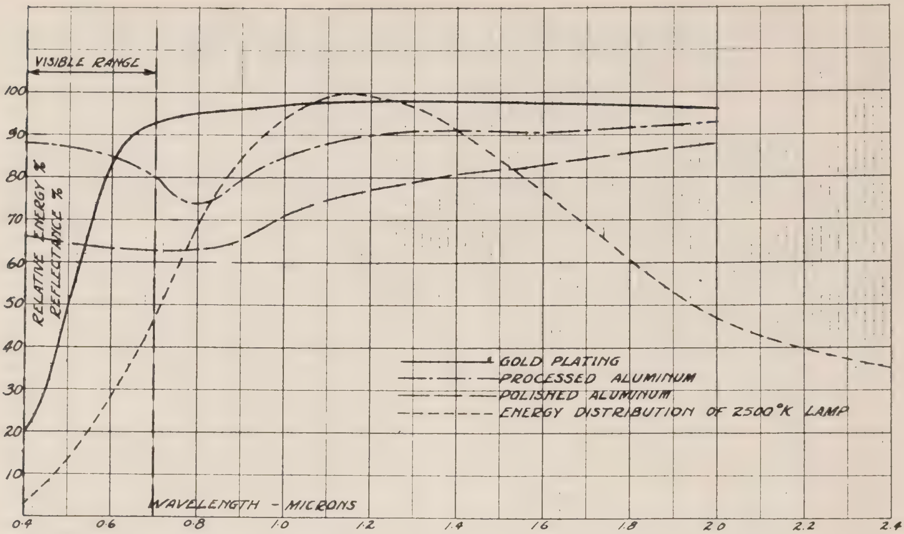


Fig. 1—Relative energy distribution of a 2500 deg. K. drying lamp and the reflectance of gold and aluminum surfaces.

particles of a liquid or gas. Heated bodies emit radiant energy in straight lines in all directions and when this energy is absorbed by another body the heat is said to be transferred by radiation and the emitted energy is infra-red radiation.

The application of infra-red radiation or radiant heating to industrial processes usually involves the utilization of the radiant energy from incandescent lamps similar to those used for regular lighting service. The lamps with their auxiliary reflectors are arranged in banks or tunnels, called ovens, and the work is passed through on a conveyor. The work is quickly raised in temperature by absorption of the incident radation and the drying or baking process proceeds.

Since the heat transfer is brought about by the absorption of the radiation incident on the work, the surface characteristics are important. Dark colours usually absorb more of the incident radiation than light colours or highly-polished materials. Fig. 2 shows the effect of different coloured paint finishes on the rate of temperature rise, with other factors constant.

The rate of temperature rise also depends on the density of the incident radiation, the mass, specific heat and conductivity of the material. The final temperature will be attained when a condition of equilibrium has been reached, that is, when the rate of heat loss from the work is equal to the rate of heat input. The rate of heat loss is dependent on several factors, the most important of which is the temperature and movement of the air surrounding the work although in the original heat transfer this has very little effect. In some of the first infra-red heating installations no attempt was made to prevent drafts which reduced the efficiency of the

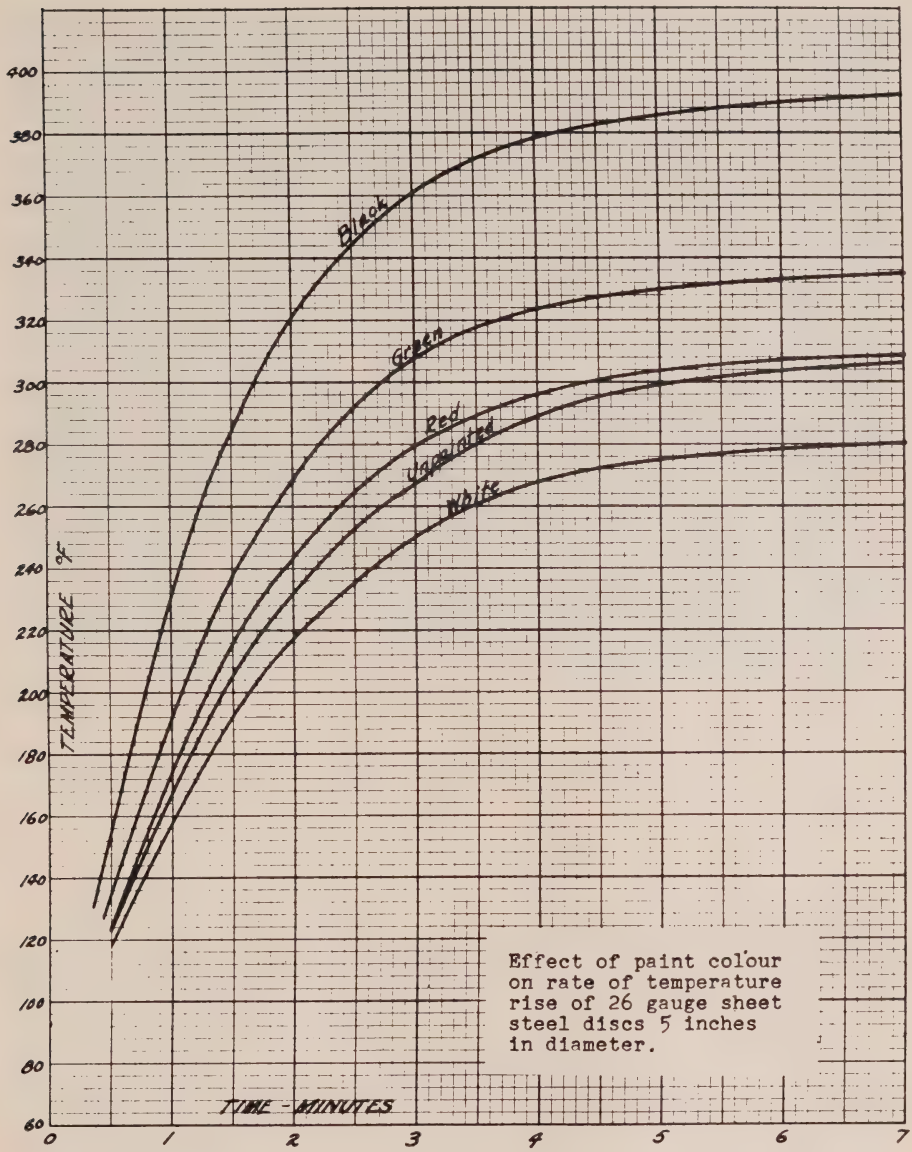


Fig. 2

oven. It is now customary to retard the movement of air in the oven by means of baffles as illustrated in Fig. 3.

As far as is known no chemical change can be attributed to the use of infra-red radiation to such operations as paint baking other than would normally take place by the application of heat by any other method. Probably the most contributory factor to the very rapid development of radi-

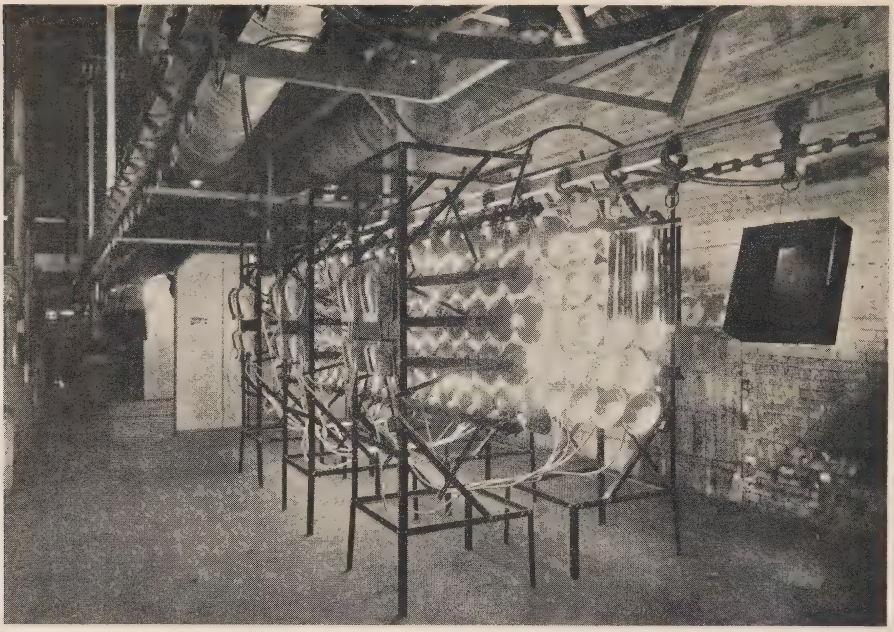


Fig. 3—(a) An installation of infra-red equipment without draught shields.

ant heating for paint baking was the development of high speed synthetic baking enamels.

It is general practice to determine the equipment required for any specific application by means of laboratory tests. The necessity for these tests is due to the presence of so many variables which make calculations difficult and unreliable until such time as sufficient data have been compiled from successful installations.

SOURCES OF INFRA-RED

The incandescent filament lamp provides a very efficient and practical source of infra-red radiation, having many advantages. From 75 to 85 per cent of the input watts to a tungsten lamp is dissipated in the form of radiant energy. The filaments in lamps used for heating service operate at a lower temperature than those used for regular lighting service, with the result that the life is greatly extended. Another desirable feature of the incandescent lamp is the relatively small filament which allows reasonably accurate control of the radiation by reflectors.

Lamps used for heating service are shown in Fig. 4. Lamps 1, 2 and 4 should be used in auxiliary reflectors. Lamp No. 3 is a reflector-drying lamp having a processed aluminum coating on the inside of the bulb and requires no auxiliary reflector.

With reasonable care the life of drying lamps should be well in excess of 5,000 hours. Many lamp failures are due to mechanical shock when cleaning or adjusting equipment due

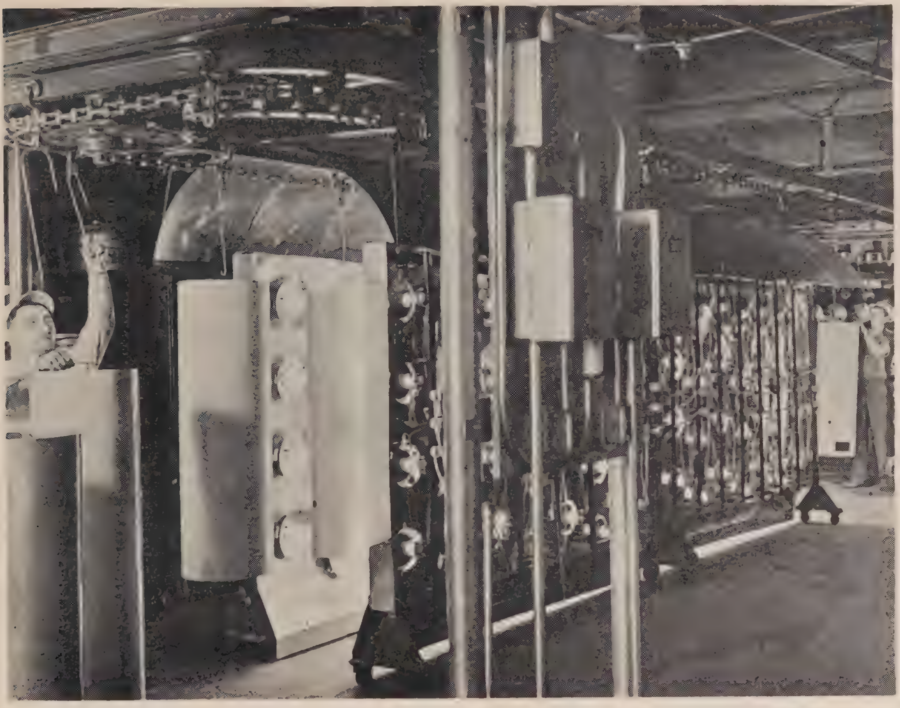


Fig. 3—(b) An installation of infra-red equipment showing the use of draught shields or baffles to minimize convection losses.

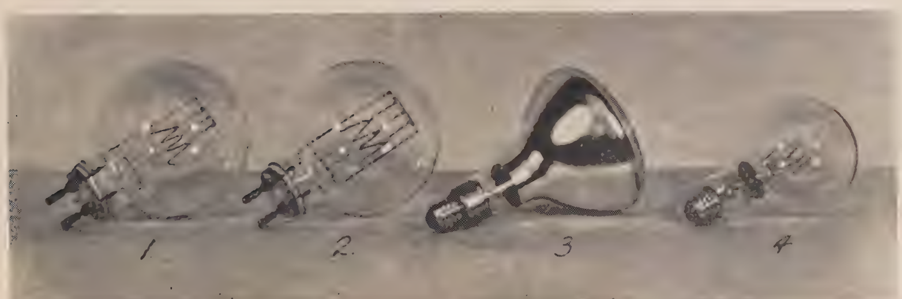


Fig. 4—Tungsten lamps used as sources of infra-red energy are:—

1. *500 watt G-40 drying lamp.*
2. *1000 watt G-40 drying lamp.*
3. *250 watt R-40 reflector-drying lamp.*
4. *250 watt G-30 drying lamp.*

Fig. 5—Some of the auxiliary reflectors used with regular drying lamps. Both open and enclosed reflectors are available. The reflecting surface is usually gold plating.

to the fact that the filaments become brittle after appreciable operation.

Reflecting Equipment

The most commonly used reflecting surface for infra-red radiation is gold plating. Gold has a very high reflection factor and does not tarnish easily. Alzak aluminum reflectors are also used having a reflection factor about 10 per cent less than gold. Processed aluminum as used on the reflector-drying lamps has a reflection factor between that of Alzak and gold. Fig. 1 shows the reflectivity of gold, processed aluminum and polished aluminum.

Several types of reflectors are available, a few of which are shown in Fig. 5. The most commonly used open reflectors range from 10 to 12 inches in diameter and are used with a 250-watt lamp. For higher heat densities with the 250 watt lamps, the smaller reflectors ranging from 7 to 9 inches in diameter allow closer spacing. Open type reflectors have hexagonal flanges to eliminate the use of draft shields behind the reflectors when they are nested in vertical banks.

Where heat is applied to a material such as wood, which has poor heat conductivity, the distribution must be uniform. Open reflectors for this purpose are deep and suitable for lamps up to 1000 watts.

Totally enclosed units are now available, using 500 and 1000 watt lamps. These types are more easily

maintained than open reflectors, as it is only necessary to clean the cover glass, which has a smooth outer surface. The molded pattern on the inside surface of the cover glass is used to diffuse the radiation and by this means a very uniform distribution can be obtained.

Regular maintenance of reflectors is imperative in order to maintain a reasonable efficiency. This is particularly important where reflectors are directly in the path of vapours or paint drippings. One method of cleaning gold plated reflectors is to apply the solvent, used in the painting operation, along with a small amount of lamp black by means of a cotton bat. When dry, the reflectors are polished with a soft cloth. Another method is to remove the reflectors and dip them in a 10 per cent caustic solution.

Paint Baking

The greatest number of applications of radiant heating to industrial processes up to the present has been for the baking of paints on metals. In many manufacturing plants the paint finishing department presents a bottleneck, preventing any increase in production rate without considerable expense. It was quite natural that considerable interest was aroused by claims that baking times for paints were reduced from a matter of hours to a few minutes by the use of infrared. All credit for the large reduction in finishing time cannot be attributed to the use of infra-red radiation, for in the majority of cases this reduction was possible only by changing the paint to one more suited to the use of radiant heating.

A general description of the constituents of various industrial finishes will point out the importance of the paint on the success of any application of radiant heating to paint baking. The most widely used industrial finishes can be divided into three general classifications, namely, lacquers, synthetic enamels and japans.

Lacquers are generally composed of plastic, plasticizer, pigment and solvent. The drying of lacquers is almost completely brought about by the evaporation of the solvent which carries the other three constituents. Neither the plastic, which actually forms the film on the material, nor the plasticizer which keeps the film flexible, are very important in connection with the infra-red drying. The pigment imparts the colour and affects the drying time, as the amount of infra-red absorbed depends a great deal on the surface colour. Lacquers sometimes contain as much as 75 per cent solvent and require a low heat density. Temperatures over 150 deg. fahr. may cause bubbling or pinholing due to the solvent evaporating too fast. Present installations of infrared drying applied to lacquers indicate 4 or 5 minutes as the usual drying time.

Synthetic baking enamels are widely used but they are not all suited to the use of infra-red radiation. The usual composition of synthetic enamels consists of pigment, oil, resin, drier, plasticizer and thinner, of which the pigment, oil and thinner are most important when considering the use of infra-red radiation. The pigment may be organic or inorganic or a mixture of both. Most organic

pigments are heat sensitive and too high a temperature will cause discoloration. In the vehicle it is customary to use various amounts of more than one kind of the several oils available. The oils are very important and they harden chiefly by polymerization* or oxidation.* Polymerizing oils, such as Tung or china wood, are necessary for high speed baking enamels which lend themselves very well to radiant heating. Oils that harden by oxidation, such as linseed, are generally not suitable as the oxidation process is comparatively slow. Thinners are of various flash-points. Those having a low flash point are called fast thinners and are necessary where the work passes directly into the oven from the spray booth. Slow thinners require a standout period. The baking temperatures for synthetic enamels range from 200 to 325 deg. fahr. with drying times as low as a few minutes. The drying time depends on the characteristics of the paint and the weight of the work.

Baking japans are not generally adaptable to radiant heating as the vegetable oil usually used requires a comparatively long time to harden. Some japans of the air-drying variety can be hardened by infra-red without difficulty.

Drying and Heating Applications

Infra-red radiation can often be used to advantage where solvents are to be evaporated or material is to be heated for further processing. It may be a case of speeding up production by supplementing existing equipment or by doing the whole job with infra-red.

For the evaporation of a film of water it is desirable to heat the film throughout for best results. This requires that the water absorb as much of the radiation as possible. On the other hand, where felts or pulp are to be dried, appreciable penetration is required. Radiation of wave-lengths longer than 1.4 microns is greatly absorbed by a thin film of water, while radiation of wave-lengths shorter than 1.4 microns is almost all transmitted by the same thickness of water. Since all sources of infra-red radiation produce some radiation beyond 1.4 microns, the temperature of the source will determine the penetration. About 50 per cent of the radiation from a regular heating lamp at 2500 deg. K. is absorbed by the first millimeter of water and it is felt that this lamp will be satisfactory for the general run of drying applications.

By estimating various factors, such as the efficiency of the equipment, absorption of the work, etc., it is possible to calculate the kilowatts required for a specific evaporation job. However, in almost all cases it is advisable to check the calculations by actual tests, as it is very seldom that all of the variables are known with any degree of accuracy. Calculated results are very useful in estimating the approximate kilowatt capacity required in order to give an indication of the economic possibilities of the use of radiant heating before spending time and money on actual tests.

For economic reasons the use of

*With reference to paints, polymerization is a change in the oil in forming, by a union of its molecules, a hardened film of higher molecular weight but possessing the same percentage composition. Oxidizing oils are those that harden by taking oxygen from the air.

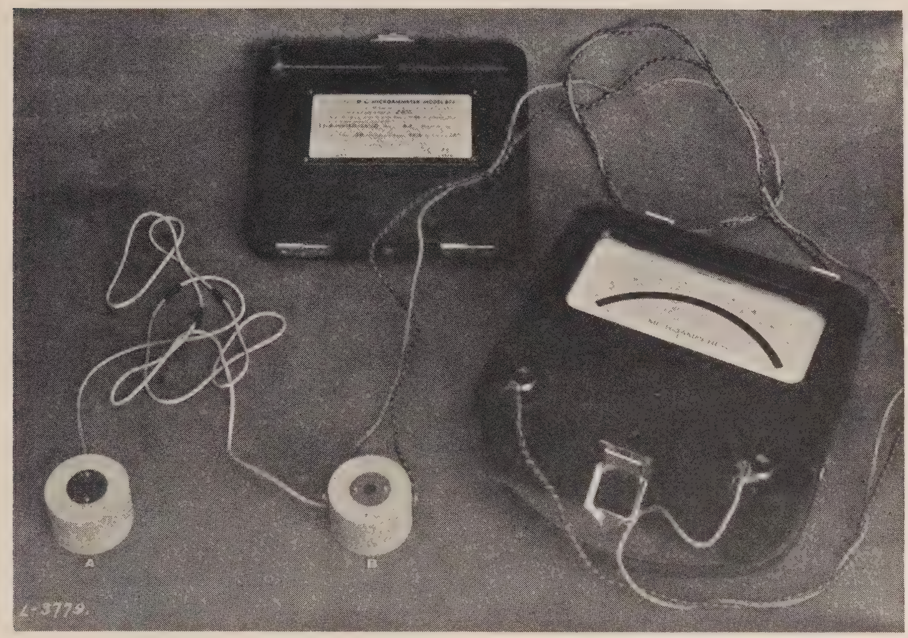


Fig. 6—Thermopile for measuring radiant energy. The hot junctions are mounted on top of holder A and the cold junctions are enclosed in B.

infra-red radiation for the evaporation of large amounts of water has not been practicable. This is due to the large quantity of heat required to evaporate the water after it has been raised to the evaporation temperature.

Infra-red radiation is used for the heating of bakelite strips previous to punching. Another successful application is the heating of asphalt impregnated fiber board to facilitate bending or forming.

Radiant heating is occasionally used on printing presses for the drying of ink on paper. There are, however, very few inks available at the present time that are adaptable to radiant heating. Anilin inks, using alcohol as the solvent, are generally suitable for infra-red drying. The drying of "printers' ink", which is a slow drying oil paint, is not suitable for the use of infra-red radiation.

MEASURING INFRA-RED RADIATION

The most commonly used instruments for the measurement of infrared energy can be divided into three general groups: bolometers, radiometers and thermopiles. For measuring the radiation from infra-red drying equipment the thermopile has been found very practicable.

The principle of operation of the thermopile depends on the generation of an e.m.f. when wires of two dissimilar metals are joined together and heated. A thermopile consists of a series of such junctions, half of which are exposed to the radiation and are

called "hot", while the remainder are shielded from the radiation and are termed "cold". In operation the hot junctions are exposed to the radiation for a certain length of time and the e.m.f. generated is proportional to the difference in temperature of the hot and cold junctions which, in turn, is proportional to the density of the radiation. A galvanometer or sensitive micro-ammeter is used to measure the e.m.f. The thermopile and indicating instrument are calibrated in watts per square inch, which is the unit of flux density used in radiant heating. The corresponding unit in lighting is the "lumen per square foot" or footcandle. Fig. 6 illustrates a thermopile with its indicating instrument.

Comments

It is quite probable that further experiments will point to the advisability of different source temperatures for certain applications. Up to the present, most infra-red work has been carried on with tungsten incandescent lamps operating at 2500 deg. K. or carbon lamps operating at 2000 deg. K. Other sources of infra-red are the hot wire element such as used in domestic radiant heaters operating at about 1500 deg. fahr., metal enclosed-type heaters operating in the neighbourhood of 1200 deg. fahr. and "black" sources operating at 1000 deg. fahr. or lower.

Infra-red heating has several operating advantages that should be given consideration along with the actual fuel costs in making comparisons with other methods of heating. Some of these advantages are short heating up period due to the direct heat transfer, controlled rate of heat transfer, elimination of warm-up time necessary for convection ovens, elimination of fumes from combustion fuels, low first cost, flexibility and light weight construction allowing ovens to be suspended from ceiling.

There has been a comparatively small amount of data compiled to date with the result that laboratory tests provide the most economical and rapid method of determining the equipment required for a specific operation. When sufficient data and experience have been obtained, factors such as the radiating efficiency and spectral distribution of infra-red sources and reflectors, reflection factors and opacities of materials to be heated will be known with sufficient accuracy to allow the calculation of the equipment requirements for a particular installation.

Interest in infra-red heating has been widespread since its first large scale industrial application several years ago and there still is a large field of unexplored uses. The majority of applications at the present time consist of paint baking, low temperature heating of metals and plastics and various drying operations.

Industrial Development in Canada to Meet the War Emergency

William D. Black, M.E.I.C., President, Otis-Fensom Elevator Company, Limited, Hamilton, Ont.

IN this war there are no exemptions. We can be very sure that before it ends each one of us will feel the impact of it in our own particular sphere and in our own particular time. That being so, it would be most unfair—in fact, it would be foolish—to claim for any one section of the community, a precedence or preeminence over the others. Total war does not create distinctions. It destroys them.

If I were not very sure that everyone, in due course of time, will be called upon to serve, I would hesitate to assert that this war has, so far, been an industrial war and, consequently, an engineer's war. It could not possibly have been otherwise. It is merely an unavoidable circumstance of modern war that its first demands are made upon industry and particularly upon those heavy industries which are almost entirely of an engineering character.

How has industrial Canada responded to these demands? I will anticipate a little by saying at once that the response has been wholehearted and effective. Obviously, the picture of wartime industrial development as a whole is something beyond the scope of individual experience. The mere statement of figures hardly suffices to convey an adequate impression for they lose their significance for us as they expand to astronomical proportions. But if we could relate our figures to some previous and comparable experience, we might expect to obtain an adequate conception of what is going on.

The evident background against which we might usefully contrast our present performances is that of the last Great War. Let us see how the Canada of to-day compares with the Canada of 1914 from an industrial point of view.

In 1914, the working population of Canada (that is, the total of all those gainfully employed) was 2,700,000. To-day it is in the neighbourhood of 4,000,000, an increase of almost 50 per cent in the past 26 years. We are bigger—numerically speaking half as big again as we were in 1914. Can we claim to be correspondingly stronger—economically and industrially?

In 1914 the total value of our exports was $432,000,000. According to the latest available figures, these have now increased to over $1,100,000,000 or a gain of more than 150 per cent. During the same period we

Radio address broadcast by the Canadian Broadcasting Corporation and sponsored by the Engineering Institute of Canada, November 13th, 1940.

advanced from eighth place to fourth place in total volume of world trade. In 1914 our manufactured exports had a value of $44,000,000. To-day they are valued at almost $700,000,000, no less than 15 times more than they were when we entered the last war.

The advances in production of raw materials during the past quarter-century have been phenomenal. Take the non-ferrous metals for example. Nature has endowed us liberally with most of these valuable and versatile metals, while she has treated our enemies with a scant courtesy which, we may well be excused for thinking. was no more than they deserved.

Since 1914 our annual non-ferrous metal exports have increased from $52,000,000 to $273,000,000 or by more than 500 per cent. Nickel production has risen from 47,000,000 lb. to 227,000,000 lb., again a five-fold increase; lead production from 36,000,000 lb. to 390,000,000 lb. up ten times; copper production from 76,000,000 lb. to 607,000,000 lb. increased eight times; zinc production from 7,000,000 lb. to 395,000,000 lb. multiplied almost 60 times.

The frequency with which favourable production figures appear in this country tends to dull their edge, but no amount of repetition can obscure the significance of such increases. They are probably without parallel in the world to-day. In other respects the list might be prolonged indefinitely. Thus the production of minerals of all kinds has quadrupled in the past 25 years. So has the production of electric power. The current production of crude oil is at thirty times the rate of 1914 and so on.

In wartime there are no more significant figures than those concerning the manufacturing industries in general. Prime Minister Churchill, with his unerring sense of the illuminating phrase, highlighted this fact for all of us when he said: "The front line runs through the factories." It would be difficult to describe the situation more graphically or accurately. In 1914 the total capital value of the industrial plant of Canada was about 1½ billion dollars. At the outbreak of the present war, it was approaching 4½ billion dollars. But we have not only trebled our manufacturing facilities since the last war. We have also improved their productive efficiency immensely. In the six years from 1923 to 1929, the physical volume of manufacturing production increased by 50 per cent while our population increased by only 11 per cent during the same period. Since 1914, the cost of materials employed, the net value of production, and the salaries and wages paid, in the manufacturing industries of Canada have all increased anywhere from 200 to 300 per cent while the number of persons employed has increased by no more than 20 per cent. Quite clearly, the increases in our total or working population convey no adequate impression of our industrial growth and expanded war potential, since we were last embattled with the Hun.

This is all very gratifying, of course, but from a war-making point of view it gives no grounds for self-satisfaction or complacency. All this rapidly developed productive capacity has been devoted exclusively to the purposes of peace. So when war

came, our great potentialities served merely to emphasize the immensity of the task which faced us in diverting our material and mechanical resources into the channels of war production. To the extent that we are called upon in Canada to produce the actual instruments of combat (aircraft, tanks, guns, shells, bombs, small arms and ammunition, explosives, and chemicals) we must secure new equipment and erect new plants.

I place new equipment first advisedly, for it is this rather than the required building that is determining the rate of expansion of our manufacturing programme. Our all-too-elastic building industry is not likely to be over-strained by immediate demands, but the production of machine tools is a very different matter. These tools, and more particularly, their ancillary gauges and fixtures, are, in fact, instruments of precision. The making of such equipment can be neither inordinately rushed nor hastily expanded. This point will bear emphasis, for it explains to a considerable degree the sense of frustration and impatience which was widespread in the early months of this year. The Canadian public, having embarked upon war, clamoured for weapons and equipment as visible evidence of our warlike intentions. At the same time, our machine tool industry, the very fount and source of all manufactures, was staggering under a colossal and unprecedented load. It is still severely strained but the initial lag or inertia has been overcome. The largest machine tool makers in this country have tripled their rate of output since the war began, have orders on hand to maintain the rate for two years, and are working to the limit of capacity. But even this kind of effort is not sufficient to provide us with the tools we need, in the time we want them. We have had to call upon the great machine tool industry of the United States and we make no mistake if we regard the accessibility and familiarity of this source of supply as a major wartime asset, not only for Canada, but for the Empire at large.

During the first year of the last war, the value of all construction of every kind undertaken in Canada was roughly $80,000,000. During the first ten months of this year, the recorded value of contracts awarded for industrial building alone was well in excess of this sum, even though many millions of dollars' worth of Government owned plant construction had not at that time appeared in the ordinary trade returns. The Director of Public Information announced on October 30th last that over $250,000,000 of purely Government owned plant construction was under way, a figure that may be contrasted with the $80,000,000 of industrial building erected in the so-called normal year 1926. The industrial building contracts awarded in September actually exceeded those of the entire year 1939 by several million dollars.

Some idea of the headlong speed of the present industrial building programme can be gathered from the fact that contracts were awarded during last September at five times the average rate of the preceding eight months.

All this huge volume of plant and equipment is, of course, but the

shadow of a dream without men to operate it. Already, the situation with regard to trained men is severe and, as to highly skilled men, actually acute. Yet the present demand for labour is, broadly speaking, of a provisional or preliminary nature and the flood tide of war employment will not arrive until the great explosive and armament plants reach full production in six to twelve months' time. How is this looming problem of industrial man-power to be dealt with? We will find no easy "royal road" to a solution, but rather a number of complementary approaches. The training of youth in technical and vocational schools, the assistance of employers in the recovery and development of skill by men who have abandoned an industrial pursuit, the recruitment of Canadian women, the provision of Government-sponsored refresher courses, will all play, and in most cases are already playing, an important part. The Dominion Government is alive to the situation and the return of suitable men from the military to the industrial front is under careful consideration. But I venture to suggest that the solution will lie, more than anywhere else, in the ability of industrial management to organize and rationalize their working forces so as to effectively employ a maximum of unskilled or part-skilled labour under a minimum of fully-skilled supervision. It is a common misapprehension to regard this labour problem as one calling for a vast number of fully and equally competent workers. This is a distorted picture of even normal industrial employment. The fact is that, given a reasonable degree of informed and intelligent direction, great numbers of workers who might otherwise be largely ineffective, will become valuable and productive industrial recruits.

As I trust I have already made clear, it is no purpose of this talk to foster the idea that what has so far been achieved, or contemplated, in an industrial way is sufficient or complete. There can be no end to the story until it ends in victory. But no harm and some good may result from a sober realization that an immense and well-considered effort is on foot througthout the country. We are only 11½ million people, but I am convinced that with our resources and an inflexible determination, we can build ourselves up to the equal of 25 millions of the best of Hitler's strained and regimental people. This is no idle boast or empty phrase. It is a legitimate and attainable war objective.

A popular question of the day is: "What are we going to do with all this industrial plant and all these workers when the war is over?" I do not profess to know. But I believe the question is, at the present time, pointless and wasteful of speculative energy which might be otherwise more usefully employed. It would be much more excusable, though quite as useless, to cogitate upon the economic advantages which we might hope to gain from a victory. Not that I believe this currently frequent question to be unanswerable or pregnant with disaster. There are a number of mitigating indications. We absorbed a great amount of the industrial development of the last war into our peacetime economy and scrapped much

more without any catastrophic results. The great depression of the thirties amply demonstrated the ability of the modern world economy to withstand great shocks and strains. The social and economic trappings of civilization are, in fact, amazingly tough and resilient. Let us go steadfastly and unflinchingly on to win this war—let us at least arm ourselves to fight it—before we begin timidly to deplore its cost. Let us march breast-forward in the certain knowledge that our grandchildren will inhabit a Canada, politically, socially, and economically better than the Canada we know to-day and find good enough to fight for.—*The Engineering Journal.*

Hydro-Electric Progress in Canada in 1940

THE annual review of hydro-electric progress in Canada prepared by the Dominion Water and Power Bureau, Department of Mines and Resources, Ottawa, indicates extensive activity in the provision of power for industry. Not only is the year's total of new plant and additional installation to existing plants the greatest of the past five years but plants containing an even greater installation are under preliminary or final construction.

Widespread extensions of transmission and distribution facilities have been made to serve new war-time industries and military establishments in addition to the normal growth of such facilities to meet ordinary civilian demands for mining, industrial and domestic use, both urban and rural.

The monthly figures of output of Canada's central electric stations, as issued by the Dominion Bureau of Statistics, reveal that each month of 1940 from January to October (the latest yet released) showed an increase in firm * power sold for consumption in Canada over the corresponding month of the previous year. Although there has been a progressive monthly reduction in the sales of electricity for use in electric boilers and for secondary export the increase in the use of firm power in Canada indicates that the total output of the central stations will achieve a new all-time record.

New water-power installation during 1940 totalled 302,790 horsepower. Adjusting this figure because of the inclusion in the 1939 totals of two installations not actually operating until after January 1, 1940 and because of the omission of two 1939 installations not reported before the end of that year gives a net addition to the total installation obtaining at

*Total electricity sold less power exported to the United States or used in electric-steam boilers.

the end of 1939 of 295,226 horsepower and brings Canada's total hydraulic installation as of January 1, 1941 to 8,584,438 horsepower.

Much of the increase was due to additions to existing installations but two new stations were completed and brought into operation during the year. The larger of these was the 178,000-horsepower plant of the St. Maurice Power Corporation (owned jointly by the Shawinigan Water and Power Company and the Brown Corporation) at La Tuque on the upper St. Maurice river, in the Province of Quebec and the other, the 7,500-horsepower Hollow Bridge plant of the Avon River Power Company on Black river in Nova Scotia. The larger additions to existing plants included a 53,000-horsepower unit installed in the Beauharnois Light, Heat and Power Company's station on St. Lawrence river and two units of 25,000 horsepower each in the West Kootenay Power and Light Company's Upper Bonnington Station on Kootenay river in British Columbia.

A description, by provinces, of the year's activities in hydro-electric construction and distribution follows:

British Columbia

The major activity in British Columbia was the completion of the extension of the Upper Bonnington, Kootenay river, station of the West Kootenay Power and Light Company and the installation of two 25,000-horsepower turbines each driving a 20,500-kv-a. generator.

After the completion of the work at Upper Bonnington the power company's construction equipment was moved to Brilliant, the only remaining undeveloped site on the Kootenay river down stream from Nelson, and work was commenced on the relocation of two miles of the Canadian Pacific Railway line. This site would provide power for an installation of 90,000 horsepower.

The Nanaimo-Duncan Utilities Limited completed the installation of a 750-horsepower addition to its plant on Millstone river, Vancouver island. This turbine is connected to a 500-kv-a. generator and is designed for use during the winter months when more water is available than is necessary for the original installation.

Northwest Territories

The construction of the first hydro-electric plant in the Northwest Territories was planned for completion in 1940 by the Consolidated Mining and Smelting Company to provide power for its Con and Ptarmigan mines. Unexpected delays have prevented the scheduled completion of the plant but it is now expected that power from it will be available early in 1941. The plant which is on Yellowknife river at the outlet of Bluefish lake, about 18 miles north of the town of Yellowknife, will contain one unit of 4,700 horsepower operating under a head of 110 feet.

Ontario

Owing to the rapid increase in industrial load at Sault Ste. Marie, the Great Lakes Power Company proceeded with the enlargement of its hydro-electric development at Upper Falls on Montreal river. The dam at this development is being increas-

ed in height and a second unit of 10,000 horsepower is being installed in the power station. It is expected that this unit will be available for operation early in 1941. Increasing the height of the dam and providing additional storage at Upper Falls automatically provides power for a possible additional unit at the Lower Falls station on the same river.

The Hydro-Electric Power Commission of Ontario was engaged in the construction of a number of projects connected with the generation and transmission of hydro-electric power throughout the Province. Investigations were also carried forward looking to new sources of power to meet future demands.

In the Patricia-St. Joseph district, the installation of unit No. 3 was completed at the Ear Falls development on the English river in January 1940. This unit has a rated capacity of 7,500 horsepower under a head of 36 feet. The turbine is of the movable blade type controlled by oil pressure from the governor. The rated installed capacity of Ear Falls is now 17,500 horsepower.

In the Georgian Bay system, a 5,000-kv-a. frequency changer set was installed at Hanover for the interchange of power with the Niagara system. Work was commenced on the construction of Big Eddy development on Musquash river. Big Eddy development will have a turbine capacity of 10,000 horsepower and contain two units with fixed blade propeller runners. The plant is expected to come into operation in November 1941.

In the Eastern Ontario system, work was begun on the construction of Barrett Chute development on Madawaska river, about five miles above Calabogie village. The development will have a rated capacity of 56,000 horsepower under a head of 154 feet, and will contain two units with Francis type turbines. A large storage dam will be constructed at Bark lake on Madawaska river. The development is expected to be available for operation late in 1942.

The South River Electric Company added a 380-horsepower unit to its plant near South River, Ontario and the Deagle Company a 160-horsepower unit to its plant at Whitefish falls on Whitefish river.

QUEBEC

The St. Maurice Power Corporation completed its new station at La Tuque on upper St. Maurice river with four units aggregating 178,000 horsepower operating under a 114-foot head. This station will provide power for the Brown Corporation's sulphate pulp mill at La Tuque and supplement the general distribution of the Shawinigan Water and Power Company.

The Beauharnois Light, Heat and Power Company completed in October, the installation of the tenth unit of 53,000 horsepower in its station at Beauharnois on St. Lawrence river. The eleventh unit is planned for operation in February, 1941 and work is proceeding on the installation of the twelfth and thirteenth units of the same capacity.

The Aluminum Power Company Limited replaced the runner on a turbine in its generating station at Chute à Caron on Saguenay river,

thereby increasing the capacity of the unit from 65,000 horsepower to 70,000 horsepower.

At The Quebec Streams Commission's development on the upper Ottawa river, the work inaugurated by the former Quebec National Electricity Syndicate, progressed steadily during the year. The plant is expected to be in operation by August 1, 1941. Its ultimate installation is 48,000 horsepower under a 60 or 70-foot head.

A further development in western Quebec is the construction of a small hydro-electric plant, 250 horsepower, by the St. Eugène de Guigues Electric Company at the outlet of Cameron lake in Temiskaming county.

The Pembroke Electric Light Company is installing an additional penstock and a 2,200-horsepower unit in its plant on Black River.

NOVA SCOTIA

Two hydro-electric generating stations were completed during the year. One of these, the Barrie Brook station of the Nova Scotia Power Commission, was included in last year's totals as it was assumed that it would be completed before the end of that year.

The Avon River Power Company, a subsidiary of Nova Scotia Light and Power Company Limited, completed and brought into operation its second generating station on Black River. It is known as the Hollow Bridge station and is at the outlet of Hollow Bridge brook. The installation operates under a net working head of 150 feet and comprises a 7,500-horsepower turbine temporarily driving a 3,500-kv-a. generator. Upon delivery of a 6,250-kv-a. generator, now on order, the 3,500-kv-a. generator will be removed for installation in the Company's third station on this river, now under construction at Hell's Gate to utilize some 70 feet of fall between the Hollow Bridge station and the headpond of the Company's White Rock station near the mouth of the river.

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Merchant Shipping in War-Time

By William Baird, Steamship Passenger Traffic Manager, Canadian Pacific Railway, Montreal, Quebec

NO review of Merchant Shipping of the United Kingdom can escape reference to the pages of history. Long before the 1500's and Henry VIII, England was engaged in the development of a Merchant Marine, and century by century—through war and peace—she made progress step by step. On occasion, the Government of the day enacted legislation to aid in the construction and the operation of ships, and at other times the initiative and industry of private enterprise were the propelling forces. Some shipping laws and regulations adopted during the present war are similar in basis to those enforced in the days of Cromwell and Charles II, and we may regard with pride the genius of the ancient fathers of such laws, that what they prescribed centuries ago still hold good.

Address to the Ontario Municipal Electric Association, the Association of Municipal Electrical Utilities and the Electric Club of Toronto at Toronto on February 5th, 1941.

In the early 1800's, the shipping position bore some relation to that at the present time. Europe was overrun by a dictator—Napoleon—who swept on from one land victory to another. William Pitt, Prime Minister of England, was beseiged by critics of his administration. There was a close blockade of the Continent of Europe by England's Navy. Napoleon, the dictator of those days—like modern dictators—tended to minimize sea power. Napoleon heard of the Battle of Trafalgar in a small village in Moravia—he said there had been a storm at sea; there had been some fighting, but pooh-poohed its importance. However, the people of England realized the significance of Trafalgar—held on and fought on to ultimate victory, with the vital aid of the Royal Navy and the Merchant Service.

Nothing is as new as the old. I should like to quote an incident in 1801. England changed its Foreign

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The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

Secretary then, just before the disappointing outcome of England's first stand against Napoleon. I give you a quotation from a letter from the outgoing Foreign Minister to his successor in 1801.

> "There is nobody to whom I would with more pleasure give up the very difficult and arduous situation which I have held than to yourself. You will find it surrounded with embarrassments in the present moment from that despicable weakness which drives the Powers of the Continent from motives of fear alone into the arms of the aggressor. My unchangeable opinion is that firmness will, and that firmness alone can extricate the country from the difficulties which the success of the aggressor upon the Continent have brought upon us."

That quotation was written 139 years ago.

In 1803, Sheridan, a Dramatist and Politician of these days, wrote an address to the people of England which was published in a Poster. It read—

> "The *enemy* by a strange *frenzy driven*, fight for power, for plunder, and extended rule—
>
> "*We*, for our country, our altars, and our homes.
>
> "They follow an Adventurer whom they fear, and obey a power which they hate. *We* serve a Monarch whom we love, a God whom we adore."

The "falling-out" of Allies, too, is not a new story. Away back in 1807, the Czar of Russia greeted Napoleon with the remark "I, too, hate the English". These words led to what was termed "an indissoluble friendship and Alliance." Five years later they declared war on each other concerning a *merchant ship sea passage* dominated by Constantinople—history may repeat itself in this area.

Prior to the Great War of 1914-18, shipping plans discussed in peace-time were based on a conception of war as a conflict between military forces, and not as now, between entire populations. Lessons learned during 1914-1918 in the war-time organization of shipping have been applied quickly and effectively in the present challenge of Democracies by Dictators.

To convey a unit by water costs approximately ½ cent; by rail 1 cent; by truck 2½ cents; by air 40 cents; and on such cheapness of water trans-

portation, is founded the intense development of modern life upon the international interchange of a wide variety of goods between widely separated nations. It is not generally realized that world sea communications are maintained by vessels which rarely exceed in number 8,000.

A nation's Mercantile Marine consists of all types and sizes of craft. For the purpose of overseas trade, experts in the United Kingdom consider only ships of 2,000 tons or over. For comparison, I may say a Duchess steamship is 20,000 tons, and a Beaver freight ship is 10,000 tons. Of such vessels of 2,000 tons and over there were in September, 1939, on the Registry of the United Kingdom 2,475 vessels of a tonnage of 15,800,000.

What happens to such vessels in war-time? A number are requisitioned immediately by the United Kingdom Government as war auxiliaries—armed merchant cruisers, transports, hospital ships. The others are good hardworking freight and passenger vessels, and their war function is to carry war supplies and food.

Naturally, in war, there is dislocation of normal sea transport. The working of the ordinary economic system is scrapped. Many ships are transferred from their accustomed routes. All sorts of strange craft poke their noses nowadays into Canadian ports. You will recall that all American vessels are barred from the Atlantic route north of Spain. Allied shipping is diverted from long voyage routes such as Australia to the short North Atlantic route between Canada and U.S.A. Ships from the United Kingdom to the Orient now take the long route via South Africa, due to Mediterranean hazards. Generally speaking a situation is created which calls for the highest degree of co-operation between the United Kingdom Government and private shipowners. As the present war engulfed almost every European Maritime nation, the Governments of the anti-Nazi regimes co-operated with the United Kingdom Government for the most suitable use of their merchant tonnage for the prosecution of the war. Four millions tons of Norwegian ships and 30,000 Norwegian sailors now sail the seas in the interests of the Allied Cause. Some examples of disruption of normal sea trading may interest you. Jamaica's banana crop is usually sold in the United Kingdom. In war it is to be sold in the United States for what it can fetch. Ships which normally carry meat to England were recently diverted to carry munitions for the Libyan campaign. Egypt's normal source of coal supply is England. In war coal is carried to Egypt from India in merchant ships.

Between 1914 and 1918 there were many bitter experiences of the lack of efficiency and foresight in the regulation and control of Allied shipping. When Mr. Lloyd George became Prime Minister in 1916, he was constrained to say in a speech:

> "Shipping has never been so vital to the life of a country as it is at present. It is the jugular vein, which, if severed, will destroy the life of the nation, and the Government feel that the time has come for taking over more complete control of all ships of this country."

Fortunately, in 1939, the United

Kingdom Government set out with the lessons of 1914-1918 well learned. On the outbreak of the war, ship voyages were subject to license by the Government, but the weakness in this system was that while the Government could say "No" to a shipowner with respect to a contemplated voyage, it did not enable the Government satisfactorily to plan ahead on a positive policy after due consideration of shipping needs in relation to the number and type of ships available. Now, all United Kingdom liners are requisitioned by the Government. War-time operating profits and losses are the responsibility of the Government, not of the owners. There is complete control also of tramp shipping.

Such merchant shipping control, and its efficient administration, with the support of the Royal Navy, is mainly responsible for the success of the campaigns in Greece and North Africa. The Navy protected the flanks of the Armies, and the merchant ships brought the supplies and men to the Armies.

In addition to the war-time control exercised by high taxation, such requisitioning ensures that war-time profits from ship operation accrue to the benefit of the entire nation, and not to a relatively few interested citizens. In the earlier periods of the last war, British Ship Time Charter rates rose from a peace-time level of 75 cents per ton deadweight to $10, and touched $12.50. Your lady friends will appreciate what such a rise in the hire of ships meant if they woke one morning to find the cost of a pair of silk stockings had risen from 75 cents to $12.50. As an indication of the difference between controlled rates and free rates, neutral ships in May, 1940, obtained $9 per ton to carry coal from the United States to South America, compared with a normal rate of $2.50.

Of course, it is to be borne in mind that costs of ship operation rise precipitately in war-time. Expenditures for a recent round voyage of an American ship show an increase of 39 per cent. However, more and more, as the war disturbs normal activity, is world shipping brought under Government control. A recent estimate published in the press indicates that 93 per cent of the world's tonnage in foreign trade has been in some way immobilized so far as free trading is concerned.

In this war all United Kingdom ship owners are paid by the Government on a uniform rate basis for the hire of the ships they own. There are various rates for various types of ships, and all shipowners are obliged to obey the dictates of the Government as to the trades in which they employ their ships, and the conditions under which they will operate.

Another form of control is that imposed by the Royal Navy in the routing of ships across the seas to avoid enemy action. The press has given publicity to the most important feature of this control—the Convoy system. Convoys are not a modern innovation. Away back in Cromwell times, Parliament passed an Act resolving "that there shall be settled and sufficient convoys to secure the trade of the nation". In 1681 Charles II issued a Proclamation which in part said,—

> "So His Majesty doth likewise declare that if any of the Subjects shall presume to adventure to sea without and before the appointed Convoy, and shall afterwards be taken captive, His Majesty will leave them under such their Misfortunes."

In 1702, plans were considered for convoying 200 British ships at one time on an eastbound Atlantic crossing.

During 1916, the average monthly losses of British ocean-going ships were 24. In the first six months of 1917, the average rose to 80. When the intense submarine campaign of 1917 was at its height, 78 ships were lost in 14 days. The average monthly loss in this war has been 34. During the entire course of the last war, the average monthly rate of loss by enemy action was 154,000 tons. For the first 12 months of this war the equivalent figure was 134,000 tons. In the war of 1812, 500 British ships were captured by the Americans in seven months—an average of over 70 a month, or 18 a week.

The rate of loss has tended to increase in recent weeks due to the bombing of ships from the air, adding to submarine attacks, but I suggest that we take heart from something that was written in the Napoleonic Wars, and which applies with singular force to-day. It was this:

> "However highly the naval transactions of Britain, and the conduct of her officers and men during preceding wars, may have tended to raise her consequence, and to inspire foreign countries at once with awe and admiration, it may be fairly asserted . . . . that no war has ever been so productive as the present of naval exertions many of them so extraordinary as to become almost incredible."

The Convoy System tends to reduce the number of voyages undertaken each year by some types of ships. A convoy of 30 or 40 ships, all marshalled in line for an ocean crossing, all of varying sizes, types and speed, may proceed only at the speed of the slowest member of the convoy fleet—thus causing a waste of tonnage, although every effort is made to minimize this handicap by trying to assemble in a convoy, ships of approximately the same speed. Moreover, concentration in convoy means an undue concentration of ships at ports of discharge, as many ships arrive around the same day instead of being spread out over a normal working week.

Mr. Churchill referred to these disadvantages in the House of Commons, London, November 5th, when he said, "When I speak of our shipping tonnage not being appreciable diminished from the beginning of the war, it must be remembered that our shipping is not so fruitful in war as in peace-time, because the ships have to go a long way round and often zigzag, and there are delays in the marshalling of convoys and congestion at ports."

Another feature of war activity which slowed up the use of merchant shipping in the early months of the war, particularly neutral tonnage, is the blockade established by the Allied fleets against Germany. In the early months of the last war, the blockade

system had many loopholes, and yet in the winter of 1916-1917 it nearly brought Germany to her knees, despite her conquering progress on land. The result was, in point of fact, only postponed until 1918. In the last war our blockade ceased at the frontiers of Germany and her Allies, but our magnificent Royal Air Force now reach inside Germany, destroy reserves of essential commodities, and disrupt transportation. The United Kingdom Minister of Economic Warfare says the Royal Air Force has paid calls on 90 per cent of Germany's refineries, and 80 per cent of her oil plants. Never forget that while Germany may have some reserves of oil, coal or other war requisites, the location of such reserves is important. With her ever spreading scenes of activities, Germany increases her transportation difficulties, and there is a problem in getting war supplies to the place where they are needed. The lack of freedom of movement of her merchant ships is a vital issue. It is little use having oil and supplies at Vancouver if they are needed promptly in Toronto.

The Soviet Army newspaper, Red Star, had this to say of oil—

> "The longer the Imperialistic War lasts the wider will be the development of operations, and the more difficult will be the problem of supplying the war with its main source of energy—oil".

While we should not bolster our courage with the thought the blockade will of itself win the war, it will have a great and a mighty influence. Mr. Tolischus, the well-known correspondent of the New York Times, attributes to Dr. Schacht this statement: "Germany began the war in the state of 1916". The United Kingdom Minister of Economic Welfare said the other day that Germany is suffering from blockade-created shortages of alloys for hardening steel, of rubber, lead, copper, textiles.

You will recall a notorious phrase of Herr Hitler: "Germany must export or die". It is estimated Germany in peace-time exported each year goods to the value of over £300,000,000 Sterling. Nowadays she can neither export or import overseas. Her mercantile fleet languishes in port, and no overseas ships can convey cargo for her, either outwards or inwards, unless with the permission of the Allied Navies. Much of Germany's merchant marine has been sunk or captured, and over 30 per cent was tied up in ports from which it had difficulty in escape. At the commencement of the war, the Royal Navy was brilliant in its dispositions in regard to German ships in neutral ports. More than half of the German merchantmen which left African and South American ports to act as supply ships for German raiders were picked up within a few days by the Royal Navy. Many others returned to neutral ports on account of the Navy's vigilance, and remain there after over 12 months of war.

Incidentally, I may say that many knotty problems arise as a result of German ships running for cover. For example, Britishers own much of the cargo of these hiding ships—a recent estimate was to a value of around 15 million dollars. Agreements were drafted and on the point of signature

last February for the release of the cargoes, but the German shipowners submitted extraneous and unacceptable demands, which caused the negotiations to break down. Legal action has been necessary in the neutral countries harboring the ships to endeavor to get release of the cargoes. Another interesting legal issue has been raised by the scuttling of German merchant ships on being stopped by Royal Navy units. The point at issue is, should scuttling a ship to prevent it from falling into the hands of the enemy be considered a legal war risk on which insurance may be collected, or is it barratry, for which the ship's master may be held criminally responsible.

One of Germany's prominent economists, writing several months ago in an important German periodical, said this:

> "We must face the facts. They are the same as in 1914-1918. England's power has brought the German overseas trade to a complete standstill."

The same economist said:

> "German ships are lying in more than 100 harbors all over the globe. Those goods and ships are blockaded by the British Navy, and part of them already have been confiscated. The whole import and export trade, particularly the exporters, made the greatest efforts to carry out Der Fuehrer's wishes; and the result is that Kiel, Luebeck, Bremen, and Hamburg are all gradually heading toward ruin."

It is said that these frank disclosures by the German economist were due to controversies between leading German personalities on the question of high trade policy. Since these words were written our irrepressible Air Force has hastened the ruin of Bremen and Hamburg.

In Italy, the same blockade effects are becoming obvious. There is a shortage of fats in Italy, as in Germany. For industry, Italy is gravely short of rubber, and is shy on copper and steel. Coal is a perpetual sore in Italy, and Germany has recently increased the price of coal she sends to Italy over her much-congested rail facilities. Normally about 84 per cent of all Italian imports arrive by merchant ships and only 16 per cent enter across land frontiers. Eighty per cent of the sea imports were carried by ships which passed through the narrow Straits of Gibraltar. Reports to the American Government indicate that due to lack of sea tanker supplies of oil, Italy is getting by the land routes only 30,000 tons of oil monthly, whereas she needs 200,000 tons each month. Every indication points to Italy's economic plans being designed to meet the needs of a very short war.

Bear in mind that ever since the proud days of the Romans, every statesman who has had to deal with the German people has recorded them as being a people who understand nothing but attack and success. They are not capable of sustained resistance and suffering such as the effective British blockade imposes. To the blockade situation and its implications, therefore, one may get a clue to the rash haste with which Germany seeks to get a quick military

decision. Germany must win a short war or lose a long one. In August, 1914, Bethmann-Hollweg said: "It will be a violent storm, but very short. I count on a war of three or at the most of four months."

During the present war, the rigid blockade measures were put into effect much earlier than in the last war, and ought to bring correspondingly quicker results. Bear in mind the wide continental area controlled at present by Germany has not heretofore been able to feed itself. It has imported foodstuffs. Another factor is that Germany is obliged to use several food commodities for articles of war. Potatoes become motor spirit. Milk is transformed into plastic materials for aircraft and fats are used for the manufacture of munitions. Moreover, the United Kingdom normally sends each year 30 million tons of coal to France, Scandinavia, Italy, and other European countries. Think of what the absence of this coal means to industrial production and transport, and to domestic comfort this winter. The conquered countries do not have rubber plantations, no large synthetic oil plants, and no material deposits of ferro-alloys. Some experts claim Germany can hold on by the use of substitutes, but take rubber as an example. No rubber can now enter Germany by sea, and her entire rubber industry was designed to work on natural rubber. To force the industry to gear for synthetic rubber demands more powerful processing machinery, and the shortage of such machinery is a bottle-neck.

The view expressed in a Report submitted by a Harvard University Group, and prepared by John D. Black, Professor of Economics of Harvard, is that if the war goes on a serious food situation will affect the entire Continent of Europe.

What does the blockade mean? The Allies, with control of the seas, dominate the sea avenues to Germany and to countries adjoining Germany.

A simple picture of the blockade is obtained if you picture a map, and have in mind that access to European ports, with two notable exceptions, can be obtained only through three narrow strips of water:

(1) The 21 miles wide Straits of Dover.

(2) The 8 miles wide Straits of Gibraltar.

(3) The 10 miles wide Straits dominated by Aden.

The Royal Navy holds power over these three inlets to Europe. The two exceptions are the 200 miles sea opening between Shetland Islands and Norway, and the Atlantic Coast ports of France. The Shetlands opening is patrolled, ceaselessly by the Naval units, but the long nights of darkness help the enemy. The care of the coast of France is a difficult naval task, as the region is infested with submarines. However, England is helped in this area by the fact that the Atlantic Coast ports of France, except Le Havre, have very limited wharf space to handle cargoes, therefore limiting the freight movement, and the Royal Air Force takes care of Le Havre by bombing it regularly.

Under the blockade, the masters of all ships destined for the very few remaining free countries of Europe

are obliged to adopt the following courses:

(1) Give an assurance, verified and certified by United Kingdom Consular Officers, that the cargo carried is not destined to, or comes from, Germany or its Axis partners.

(2) If such assurance does not cover all the cargo on board, the ship is stopped at sea and the master may be directed to take his ship to an Allied port. There the cargo is examined to check its bona fides.

Shipping delays due to the blockade are minimized by the operation of the Navicert System in the United States and elsewhere. The system was the invention, in the last war, of an American Consul-General in London, and consists of the granting by British Consular officers, after appropriate application and examination, of commercial certificates to exporters in the United States, South America and around the world. Such certificates accompany the freight on a ship and provide immediate assurance to Royal Navy units that the freight is not contraband. In other words, neutral exporters may ascertain in advance whether at time of shipment there is likely to be any Allied objection to any particular consignment of goods passing through the blockade. A passenger has a passport to facilitate his travel across frontiers, and bona fide commercial freight may now get a passport to cross the frontier of the Allied blockade. This system ensures the blockade operating on the wharves in port as well as at sea. Since August 1 over 20,000 applications were received for Navicerts of which only 11,000 were issued.

As some indication of the effectiveness of the blockade, goods seized in one year by order of the United Kingdom Contraband Committee alone amount to more than 750,000 tons. To bring this figure to a more understandable unit, it represents around 30,000 railroad cars of freight or 857 trains of 35 cars each. To this total must be added a still larger volume of freight which would have started on its way to enemy-controlled countries, but did not do so on account of the efficiency of naval patrols. Take note of this blockade point. The Republics of South America, and the United States, have been dependent in peace-time upon the markets of Europe, including the United Kingdom, for about 44 per cent of their surplus production. This entire trade to Europe is barred to all Europe except with the permission of the Royal Navy.

Another system of ship control was publicly announced recently by Mr. Dalton, Minister of Economic Warfare. Ship Warrants are issued to ships engaged in overseas trade associated with the Allied Cause. About 75 per cent world shipping has such Warrants. Trading is made difficult for ships without a British Warrant and which are endeavoring to operate against the Allied Cause. British-controlled commercial facilities are world wide—bunkering, fresh water, stores, repairs, marine insurance, credits, and these facilities may be refused to a ship without a Warrant.

You will recall a remark of Lord Curzon in the last war that "The

Allies floated to victory on a sea of oil". The purchase and shipment of petroleum in the United States to Germany during the last four years before the war showed a greater increase than those to any other European market, presumably an effort to accumulate reserve stocks for war purposes. The Allied blockade has effectively blocked all overseas supplies of oil to Germany, and you probably observed the other day an appraisal of an oil expert in the United States who had this to say:

> "The Germans are shy on their minimum requirements in the neighborhood of 2,000,000 tons of oil. Therefore, the moment the reserve stocks—to which can be added the 4,000,000 tons from the captured countries—have been consumed, Germany will be desperate for petroleum. If the estimate of an annual consumption of 15,000,000 tons for the Nazi blitzkreig machine is correct, then Germany will be in a bad shape very quickly."

A recently published estimate of the total Nazi oil supply within the next 12 months amount to 129 million barrels secured from Roumania, from German production, from countries under German control, and reserves and booty. Such a figure of 129 million looks big, but in 1939 the civil consumption—not war consumption—of Continental Europe was 230 millions barrels. It is true, civil consumption can be drastically cut in war, but only at the expense of industrial activity and of transportation facilities.

Bear in mind that while England cannot blockade Germany from the land side to the eastward, transportation difficulties help the Allies. The great water highway of the Danube from the Balkans freezes for several weeks each winter, and many vast stretches of Eastern Europe have not modern automobile highways to relieve the strain. On the railroad situation, Germany is short of freight cars, and is seizing all the cars she can lay hands upon in conquered countries. Ever since the advent of the Nazi regime the railroad system of Germany has been neglected, and the tremendous strain of seven years' war preparation is being revealed in mishaps, break-downs, and other operational weaknesses. The policy of guns for butter was matched by airplanes for railroads.

While war dislocates overseas general trade, one notes with pride that the imports into the United States from the United Kingdom increased by value 80 per cent in a recent month compared with the average of prewar month. In July last 25 per cent more shipping left United Kingdom ports with cargoes for all ports in America compared with more peaceful periods. Exports through New York to the United Kingdom rose from about 15 million dollars in July, 1939, to 71 millions in July, 1940. Such war-time trade could only be undertaken by the Royal Navy's domination of the seas and the Merchant Navy's extraordinary versatility.

As is experienced in all aspects of national life, one form of governmental control leads to another. Having secured control of the ships to carry supplies, the United Kingdom

Government soon felt obliged to control ship cargoes themselves. Such control eased the responsibility of shipowners who were engaged in practical problems of ship management, and placed the selection of cargoes on those whose function was to study and to know the relative importance of cargoes.

Like all Government regulatory systems, the cargo control system has its weaknesses. As one expert says of the last war:

> "If barley for brewing is excluded as an import, the brewers will buy the home barley that would otherwise have gone to feed pigs, or been used in the manufacture of munitions, and an extra demand for imported barley will be made on the unquestionable ground that it is wanted for munitions or for the essential meat supplies of the country."

During this war England may have a disaster—a shortage of beer. Transportation difficulties may cause the introduction of beer rationing.

Ship control leads to cargo control, and cargo control leads directly or indirectly to control of the purchase of commodities. The United Kingdom Government now have direct control of the acquisition and distribution of the main articles of food and raw material. The Government itself determines how much wheat, or timber, or metals, or sugar it desires to have, and selects the ships to carry it. In this connection the Ministry of Food of the United Kingdom is now the world's largest international purchaser of food, and the ocean movement of overseas food purchases is a vital shipping problem.

There are a few brief sidelights on Merchant Shipping in war. They relate more to policy than to personnel, but it is unnecessary to stress to a Toronto audience the deeds of distinction performed almost daily by the masters, officers and men of the Merchant Service, who are civilians carrying on peace-time work. Many of them are above age at which men are called up for military service. If they desired they could stay ashore, but their pride and courage takes them again and again to sea. It is the courage of free men fighting for freedom. Here is an extract from a report of a ship in Convoy—

> "Late afternoon—It is bitterly cold. Snow squalls hide the shore, and snow is crusting on deck. The crew of one of the guns installed for defence is playing "follow the leader to keep warm. The Captain wears a heavy wool-lined canvas coat over layers of sweaters, fleeced lined boots, fur-lined mittens and then gloves. His head is covered by a knitted wool helmet. He does not look like the officer who recently was honored by The King with the Distinguished Service Cross."

Will you think of these Merchant Seamen coming and going, without publicity and without fuss; their daily challenge to the efforts of the enemy, on sea, under the sea, and in the air; and the untold value of their work to carry supplies for the Allied Cause. Truly do such men merit commendation from the peoples of the Empire.

Dr. T. F. Robertson Brockville

Dr. Thomas F. Robertson, Commissioner of Brockville Public Utilities Commission passed away at his home in Brockville on the evening of Wednesday, December 29th, 1940, in his seventy-second year.

Dr. Robertson, who would have completed 50 years in the practice of medicine in the course of a few weeks, was born in Spencerville, Ontario. In 1891 he graduated in medicine from McGill University, Montreal, and immediately entered into practice in Brockville, where he remained ever since, attending to a large practice until his final illness.

In public life, he took a keen interest in the welfare of the community. He served for some years on the Board of Education, and in 1922 was elected to the Brockville Public Utilities Commission, of which he continued a member until the time of his death. During his service on the Commission he was Chairman in 1924, 1927, 1929, 1932, 1935 and 1938.

In addition to his interests in Brockville and the medical profession, he operated a farm east of Maitland, where he specialized in breeding Holstein-Friesian cattle, and served as an officer of Holstein organizations in the district.

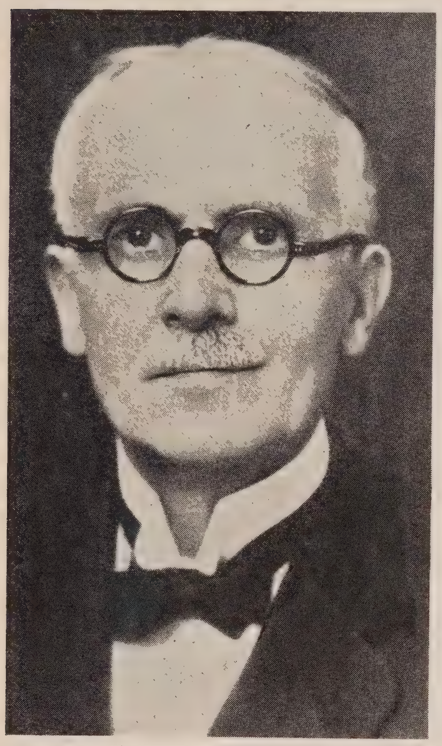
Dr. Robertson was revered for his kindly disposition, and certainly will be missed on the Brockville Commission. First and last he was a gentleman.

Rev. F. C. Elliott Ingersoll

On Friday afternoon, January 24th, 1940, Ingersoll suffered a severe loss in the death of Rev. Frederick Charles Elliott, Chairman of the local Public Utilities Commission. He would have been 70 years old had he lived until next August.

Mr. Elliott was born at Culloden in Dereham township, Oxford county. His family was distantly connected with Nancy Elliott, the former Vienna, Ontario, school-teacher, who was the mother of Thomas Alva Edison.

On graduation from Woodstock Baptist College, he entered the min-



istry of the Baptist Church, serving at Port Rowan, Waterford, Toronto, Haileybury and Goderich. In 1929 he resigned his pastorate at Goderich and went to Ingersoll, where he lived retired until a few years ago when he took charge of the Beachville Baptist Church.

As a resident of Ingersoll, he was keenly interested in the affairs of the community. He served for a term as President of the Ingersoll Chamber of Commerce after which, in December, 1932, he was elected to the Public Utilities Commission for a term of two years, and since then has served there continually until his death. In 1934 he was elected Chairman of the Commission, which office he held each succeeding year excepting in 1939.

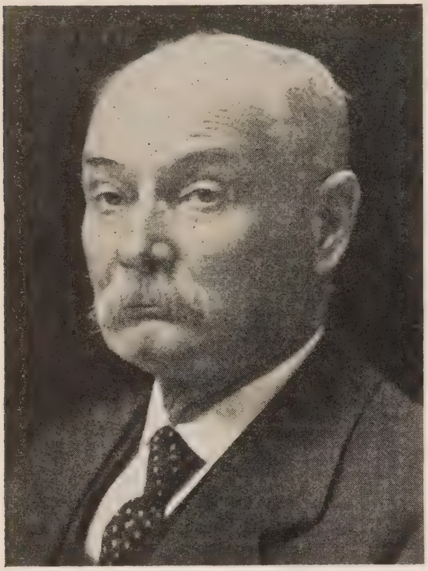
His ability was soon recognized at meetings of the Ontario Municipal Electric Association, when he was elected as vice-president. In 1938 he was elected president of the O.M.E.A., and again in 1939. Since then he has been an honorary vice-president. He was also a member of the Municipal Hydro-Electric Pension and Insurance Committee.

Mr. Elliott had a broad outlook upon life and was tolerant of the viewpoint of others. He possessed a delightful humor and was a cheerful companion. A good citizen and faithful pastor, he enjoyed a unique place in the regard of his community, and also of the Hydro organization.

W. T. Dudley, Midland

William T. Dudley, who for over thirty years was a member of Midland Public Utilities Commission, died at his home on Monday, February 10th, 1941. He was in his seventy-eighth year, thirty-nine of which had been spent in public service to the town of Midland.

Born at Zion near Cannington, he spent his early manhood in the employ of the Grand Trunk Railway on track construction and yard work, and for a while in a machine shop in Lindsay. In 1893 he was sent to Midland as engineer in the old Midland Forwarding Company elevator, which post he held for twelve years. He was then made inspector of railway water services of the Northern Division of the Grand Trunk Railway, covering ground between Toronto and North Bay and as far east as Peterborough.



When the Aberdeen Elevator was completed at Midland, he was made chief engineer, which position he filled until recently.

His municipal record started when he was elected to the town council, where after three years of service he became mayor, and it was during his term of office that the Duke of Devonshire visited Midland. On the formation of the Water and Light Commission, afterwards the Public Utilities Commission, he was made a member and has served there continuously until his death. Midland was the first municipality in the Georgian Bay system to enter into a contract with The Hydro-Electric Power Commission for a supply of power from Big Chute, and this was due largely to Mr. Dudley's efforts. During the thirty years that Midland has been taking power, he has always been a staunch supporter of Hydro and has worked continuously for its success.

Mr. Dudley's long, unbroken period of service in the interests of Midland reflect his happy, genial disposition. Not only in his home town, but in other parts as well as among his Hydro associates, he had a host of friends who held him in the highest esteem.

He was proud of his Irish ancestry, his father being from Cork and his mother from Caven. He used to say that he would be ashamed to be anything else than an Irishman.

Big Chute development, Severn river.

The Winter Convention

THE 1941 Winter Convention of the Ontario Municipal Electric Association and the Association of Municipal Electrical Utilities held at Toronto, on February 4th and 5th, had two sessions that were held jointly by the two associations. At one of those sessions, where it had been arranged to have Dr. T. H. Hogg, Chairman of The Hydro-Electric Power Commission of Ontario speak, owing to Dr. Hogg's inability to attend on account of illness, Hydro Commissioner J. Albert Smith gave an address entitled "Hydro is Prepared". Another feature of the same session was the showing of the Hydro sound film, "The Bright Path". The other joint session was devoted to a paper given by H. D. Rothwell, Assistant Engineer, Municipal Engineering Department and Chairman of the Truck Committee of The Hydro-Electric Power Commission of Ontario on "Utility Transportation".

In the A.M.E.U. separate sessions there were two papers and also two others at the Breakfast Session arranged by the Committee on Accounting and Office Administration. In a paper, "Power Arcover Damages, Overhead Line Conductors", G. A. Matthews, Inspection and Equipment Engineer, Electrical System of the Detroit Edison System described experimental and development work done by his company on this subject. By means of demonstration equipment, G. F. Mudgett, Manager Illumination Department, Canadian Westinghouse Company, Hamilton, described, "The Fluorescent Lamp—Its Auxiliary Equipment and Operating Characteristics". "Storing Records" was the subject discussed by Allan McKenzie, Archivist of the Canadian Bank of Commerce, Toronto, in his address at the accounting session; and Robert Jarvie, Accountant of the Public Utilities Commission of Windsor, read a paper on "Accounting, Ancient and Modern."

Following the paper on Utility Transportation two resolutions were adopted. One of these resolutions provides for the formation of a Utilities Transportation Committee to study and report on all problems connected with utility transportation. The second resolution named H. D. Rothwell as Chairman of the Utilities Transportation Committee who was empowered to make up his committee from the A.M.E.U. membership.

There were collections taken during the convention in aid of the British War Victims Fund; the total money collected for this purpose amounting to $270.45.

* * * *

O. M. E. A.

During the O.M.E.A. sessions of the convention the following resolutions of general interest were adopted.

Re: Municipal Hydro-Electric Pension and Insurance Plan:

"THAT, as the matter of Pension and Insurance only affects sixty Municipalities; AND, as the letter advising these Municipalities of the proposed changes in benefits was only

sent out on January 23rd last, and as a result, the Commissioners have not as yet had an opportunity to go into this matter thoroughly,—BE IT RESOLVED THAT we do not discuss this matter at this time; but that the President of this Association be instructed to call a meeting of all Municipalities who participate in the Municipal Hydro-Electric Pension and Insurance Plan, some time in March, to discuss the proposed changes in Benefits—that the objects of this meeting be set forth in the notice—and that we ask Professor M. A. Mackenzie, Actuary to the H.E.P.C. of Ontario, to attend this meeting, together with representatives of the Hydro-Electric Power Commission of Ontario Legal Department, representatives of the Confederation Life Association, and the members of the Municipal Hydro-Electric Pension and Insurance Committee."

Re: Summer Convention, 1941:

RESOLVED THAT the Ontario Municipal Electric Association shall not hold a Summer Convention in 1941.

Re: War Savings Campaign:

RESOLVED THAT the Ontario Municipal Electric Association endorses the War Savings Campaign, and asks that all our Commissions cooperate by endeavoring to have their employees come under the scheme.

Re: Deceased Members:

THAT suitable resolutions be prepared and placed on the Minutes of this Association regardng the contributions made to the development of Hydro in Ontario and to this Association by Mr. T. J. Hannigan, Mr. F. C. Elliott, and Dr. J. S. Boyd, all of whom were former officers of this Association, and who have passed away during the past year.

Officers elected for 1941 are as follows:—

Honorary-President: Dr. T. H. Hogg, Chairman, H.E.P.C. of Ontario.

Honorary Vice-Presidents: T. A. McFarland, London; Jos. Gibbons, Toronto; F. Biette, Chatham; G. S. Matthews, Peterborough; C. J. Halliday, Chesley; John Kalte, Hanover.

President: Dr. W. J. Chapman, St. Catharines.

Vice-Presidents:

District No. 1—W. R. Strike, Bowmanville.

District No. 2—A. Menary, Grand Valley.

District No. 3—J. R. Pattison, Fort William.

District No. 4—K. A. Christie, K.C., Toronto.

District No. 5—Keith MacLeod, Stamford Centre.

District No. 6—E. L. Box, Seaforth.

District No. 7—P. R. Locke, St. Thomas.

District No. 8—Garnet Edwards, Windsor.

Acting Secretary-Treasurer: Miss K. Ciceri, Guelph.

District Directors:

District No. 1 — Jas. Halliday, Kingston; M. P. Duff, Belleville.

District No. 2—R. D. Boyes, Alliston; W. V. Brown, Meaford.

District No. 3—M. P. Benger, Port Arthur; R. G. Walsh, Port Arthur.

District No. 4—E. W. McCulloch, Brampton; E. W. Grant, New Toronto.

District No. 5—C. D. Hanniwell, Niagara Falls; R. Peirson, Brantford Twp.

District No. 6—H. O. Hawke, Galt; F. H. May, St. Marys.

District No. 7—J. B. Hay, London; B. N. Downing, Beachville.

District No. 8—Geo. N. Galloway, Sarnia; F. A. Fitzgerald, Petrolia.

* * * *

A.M.E.U.

There was but one A.M.E.U. committee report submitted, namely that of the Rates Committee, which was adopted. Referring to the Committee on Accident Prevention and Health Promotion, notice was given of a motion to be presented at the next convention of the association to have that committee discontinued.

The following officers were elected for the year 1941:

President: C. E. Brown, Meaford.

Vice-President: V. A. McKillop, London.

Secretary: S. R. A. Clement, H.E.P.C. of Ontario, Toronto.

Treasurer: George E. Conn, H.E.P.C. of Ontario, Toronto.

Directors (from the membership at large):—

G. E. Chase, Bowmanville; O. M. Perry, Windsor; P. B. Yates, St. Catharines.

District Directors:

Niagara District—R. S. Reynolds, Chatham.

Georgian Bay District—R. S. King, Midland.

Central District—C. A. Walters, Napanee.

Eastern District—R. J. Smith, Perth.

Northern District—R. B. Chandler, Port Arthur.

Standing Committee for the year were drafted at a meeting of the Executive Committee held during the Convention as follows:—

Papers Committee: G. E. Chase, Bowmanville, Chairman; A. W. Bradt, Hamilton; J. W. Peart, St. Thomas; C. E. Schwenger, Toronto; C. W. Hookway, Canadian Westinghouse Company, Toronto; H. D. Rothwell and M. J. McHenry, H.E.P.C. of Ontario, Toronto.

Convention Committee: V. A. McKillop, London, Chairman; J. E. B. Phelps, Sarnia; J. E. Teckoe, Jr., Tillsonburg; F. A. Mahoney, Canadian General Electric Company, Toronto; E. G. McCracken, Sangamo Company, Toronto; W. R. Greenshields, Canada Wire & Cable Company, Toronto; W. Dixon, Canadian Westinghouse Company, Toronto; D. C. McKellar, Northern Electric Company, Toronto; J. N. Wilson and D. G. Ferguson, H.E. P.C. of Ontario, Toronto.

Regulations and Standards Committee: R. B. Chandler, Port Arthur, Chairman; S. W. Canniff, Ottawa; P. B. Yates, St. Catharines; O. H. Scott, Belleville; R. L. Dobbin, Peterborough; T. R. C. Flint, Toronto; W. R. Catton, Brantford; A. B. Manson, Stratford; C. J. Moors, Fort William; A. G. Hall, W. P. Dobson and J. J. Jeffery, H.E.P.C. of Ontario.

Committee on Accident Prevention and Health Promotion: R. J. Smith,

Perth, Chairman; P. B. Yates, St. Catharines; J. E. B. Phelps, Sarnia; C. E. Schwenger, Toronto; J. W. Peart, St. Thomas; R. Harrison, Scarborough Twp.; V. A. McKillop, London; R. L. Dobbin, Peterborough; A. B. Manson, Stratford; A. W. Murdock, B. Mulholland, V. A. Beacock and Wills Maclachlan, H.E.P.C. of Ontario, Toronto.

Merchandising Committee: O. M Perry, Windsor, Chairman; O. H. Scott, Belleville; F. S. Rhoads, Windsor; R. W. Turner, Hamilton; R. S. Reynolds, Chatham; H. R. Hatcher, Galt; A. W. J. Stewart, Toronto; O. C. Thal, Kitchener; F. Wilkinson, London; E. Parsons, Sarnia; R. Robinson, Stratford; S. W. Canniff, Ottawa; R. L. Dobbin, Peterborough; J. W. Peart, St. Thomas; M. J. McHenry, W. Dymond and J. J. Jeffery, H.E.P.C. of Ontario, Toronto.

Rates Committee: P. B. Yates, St. Catharines, Chairman; W. R. Catton, Brantford; A. B. Manson, Stratford; G. E. Chase, Bowmanville; O. H. Scott, Belleville; O. M. Perry, Windsor; R. S. Reynolds, Chatham; T. R. C. Flint and F. W. Peasnell, Toronto; R. B. Chandler, Port Arthur; A. W. Bradt, Hamilton; V. A. McKillop, London; J. J. Jeffery, G. F. Drewry and S. R. A. Clement, H.E.P.C. of Ontario, Toronto.

Committee on Accounting and Office Administration: C. A. Walters, Napanee, Chairman; Geo. Appleton, Toronto, Vice-Chairman; R. S. King, Midland; H. R. Hatcher, Galt; A. B. Manson, Stratford; J. W. Hammond, Hamilton; W. E. Wallace, Windsor; M. A. Gough, East York Twp.; C. W. Eastwood, London; P. E. Battram, Sarnia; Ralph C. Parker, Penetanguishene; A. M. Bowman, Elmira; R. E. Ditchburn, Strathroy; H. Clegg, Peterborough; T. W. Houtley, Welland; M. W. Rogers, Carleton Place; A. D. Nelson, Kingston; W. M. Salter, Barrie; G. W. Grabb, Chesley; O. H. Scott, Belleville; Wm. Tait, Picton; R. H. Martindale, Sudbury and R. M. Bond, H.E.P.C. of Ontario, Toronto.

Auditors: H. P. L. Hillman, Toronto and W. G. Pierdon, H.E.P.C. of Ontario, Toronto.

Upstream view of Tretheway Falls development, South Muskoka river.

Power Arcover Damages Overhead Line Conductors

By George A. Matthews, Inspection and Equipment Engineer, Electrical System, The Detroit Edison Company, Detroit, Michigan

THE Detroit Edison Company decided some time ago that too many conductors were being dangerously damaged by power arcs on its 4,800-volt overhead lines of the distribution circuits, and opened a project to find ways and means to reduce arc damage and the number of falling wires.

This Company operates 55,000 conductor miles of wire in its overhead 4,800-volt distribution system. In the years of 1938 and 1939, there were, respectively, 703 and 993 cases of trouble in distribution circuits in which wires fell to the ground. (See Exhibit A in the Appendix to this paper.) This is good performance; the expectancy of wires down is only one break per year in 65 miles of wire, but further analysis brought out the facts that at least 50 per cent of the cases of wires down were initiated by transient causes and that the arcs resulting therefrom would not have seriously damaged the wire if they had been limited to a shorter duration. Furthermore, it is obvious to all operators that the number of wires down should be kept to an absolute minimum for reasons other than reducing customer outage. It naturally follows that, if the number of wires down can be reduced, service continuity and customer outage will be improved proportionately.

Distribution circuit performance records were available, which when studied, showed that nearly all conductor failures were caused by power arcover damage that had occurred during electric, wind or sleet storms. The exceptions were mostly cases where foreign conducting objects were drawn or thrown into the line conductors subsequently to cause power arcs. Therefore, it seems that the causes that produce the greatest number of power arcovers in overhead distribution lines will remain outside of our control. It is apparent then, that power arcovers are inevitable and the problem becomes one of accepting the arc on these conductors and of providing protective equipment by which the duration of the arc will be limited in overall time, and to such an extent that the damage will not be objectionable.

With this theory in mind, a study of the behavior of conductors under power arcover was made. It was found that:

1. With time-delay or "instantaneous" operations of conventional switchgear, serious damage to conductors could not be prevented.
2. To protect conductors against burndown, the duration of arcing must be limited to values of ½ to 2 cycles (60 cycle basis), depend-

ing upon the size of conductor and the amperes in the arc.
3. Switchgear meeting these overall time requirements was not available in the usual markets.
4. It would be necessary to develop new switchgear if the object of the project was to be accomplished.

The equipment finally developed has been thoroughly tested in the laboratory and found to meet the performance specifications. Some of this equipment has been in trial service in the Detroit area for one year. It has performed satisfactorily throughout this time. It functions to clear an arc in ½ cycle with restoration of voltage in 6 cycles total time. More of this equipment is now being installed for trial purposes.

Although actual trial operating experience is limited to one year, it is felt that presentation of the laboratory data concerning arc damage to conductors and a description of the newly developed equipment will be of interest.

Method of Testing

For the purpose of these tests an experimental line was set up in an outdoor laboratory so that test conditions would simulate actual service conditions. Tests were made with horizontal conductor spacings of 28, 50 and 88 inches, and with varying vertical spacings up to 48 inches. Both bare copper and bare aluminum conductors were included in the tests as well as covered copper wire. Tension in the line was made to conform with regular practice for each size of wire. All tests were made single phase at 5,000 volts, ungrounded. The current was varied from 100 to 5,000 amperes.

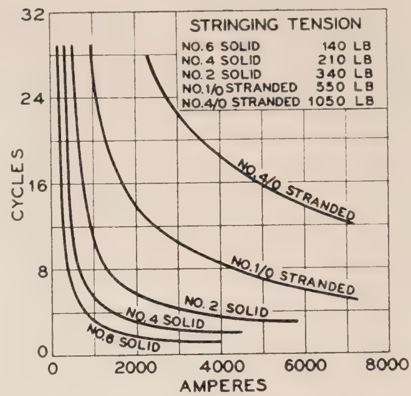


FIG. 1

BURNDOWN CHARACTERISTICS OF COVERED COPPER WIRE AT 5000 VOLTS CONDUCTOR SPACING 28 INCHES

Short circuits were initiated in the following manners:
1. Tree limbs of soft and hard woods, both green and dry, were placed across the line.
2. The condition of conductors momentarily swinging together was simulated by tying the wires together at midspan with No. 40 copper magnet wire.
3. Power arcovers between conductors at rest were initiated by pulling a single thread of No. 40 copper wire across the line.

Electrical and time measurements were made with a magnetic oscillograph, and the extent of damage to conductors was measured by the usual laboratory methods.

Test Results

Ampere-time capacity of an arc to fuse conductors is shown in Fig. 1.

The time scale in the figure represents the interval between the instant the arc was established and the instant the metallic continuity of the circuit was broken. In other words,

TABLE I

DECREASE IN TENSILE STRENGTH OF INSULATED WIRE DUE TO ARC-CURRENT DAMAGE

Arc-Current, Amperes	Duration of Arc, Cycle	Tensile Strength of Arc-burned Copper, Lb.	Reduction of Tensile Strength	
			Lb.	Per Cent.
No. 6 Covered copper wire—Initial tensile strength, 1,165 lb. (Average of six specimens)				
400	......	1020	145	12.4
700	1	990	175	15.0
1000	¾	970	195	16.8
1100	¾	940	225	19.3
1500	⅝	830	335	28.8
1900	½	795	370	31.8
No. 4 Covered copper wire—Initial tensile strength, 1,680 lb. (Average of three specimens)				
2500	¾	1265	415	24.7
4300	⅝	1225	455	27
No. 2 Covered copper wire—Initial tensile strength, 2,820 lb. (Average of three specimens)				
4300	⅝	2315	505	17.9
7000	½	2225	595	21

it does not include the time that arcing continued after the wires broke.

It can be seen from the curves that any arc of current and duration represented by a point to the right of a given curve will result in fusing of that size of conductor. Any combination represented by a point to the left of the curve will not cause complete mechanical failure of the wire but will cause some degree of damage. To determine the extent of such damage, conductors were subjected to arcs of various current magnitudes and durations short of burndown. The wires thus damaged were later tested to determine the loss of mechanical strength. Table I shows the results of the tests on No. 6, No. 4 and No. 2 conductors in which the duration of arcing was held to one cycle or less. It can be seen that even with high values of currents shown, the extinction of the arc within one cycle leaves the conductor sufficiently strong to withstand most any mechanical stress to which it might be subjected in service.

In general No. 6 wire, when built into lines, is applied so that the tensile stress will not exceed 560 lb. For No. 4 and No. 2 wires these figures are

920 and 1200 lb., respectively, under the most severe loadings anticipated.

These facts concerning the capacity of arcs to do damage to covered conductors led to the decision that, if wires were to be saved from objectionable damage, switching speeds shown in the following tabulation would have to be accomplished where currents of the value shown are encountered.

manufacturing sources. Furthermore, no promising commercial developments were in sight.

One consideration involved in such development was that many existing circuits were equipped with conventional switchgear connected for time-delay or "instantaneous" relaying and reclosing which were features to be retained. That such switchgear could

Size of Conductors	Current Range, Amperes	Switching Speed Necessary, Cycles	Maximum Current with 2 Cycle Switching, Amperes	Maximum Current with 1/2 Cycle Switching, Ampères
No. 6	100- 500	2 to 3	500	....
	500-1,000	1 to 2	....	....
	1,000-1,900	½ to 1	....	1,900
No. 4	100-1,000	2 to 3	1,000	....
	1,000-2,000	1 to 2	....	....
	2,000-4,300	½ to 1	....	4,300
No. 2	100-2,000	2 to 3	2,000	....
	2,000-5,000	1 to 2	....	....
	5,000-7,000	½ to 1	....	7,000

Two cycle circuit clearances will adequately protect No. 0 copper with currents up to 7,000 amperes and No. 0000 up to 10,000 amperes, which current values are of the maximum order encountered in field service.

The next phase of the problem, therefore, was the development of switching equipment physically and economically suitable for use on distribution circuits and possessing all of the features of conventional switchgear plus the ability to give initial interruptions in an overall time varying from ½ to 2 cycles, and extremely fast reclosing. As previously stated, a survey of commercially available equipment had indicated that devices fulfilling all of these requirements were not to be had from regular

not be modernized by alterations to give anything like ½ or 2-cycle overall arc-clearing time is indicated by the fact that the inherent arcing within the breakers themselves, after the contacts part, is about 2 cycles.

Fig. 2 shows that fuses do not offer the protection sought here.

Fast Switching Equipment

Three switching devices have now been produced and proved in the laboratory. One device, called a "Shorting Contactor" is designed for applications to circuits equipped with con-

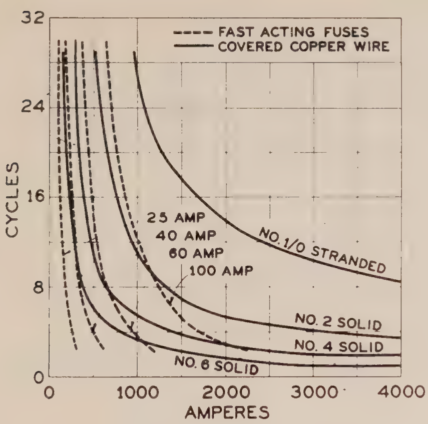


FIG. 2

COMPARISON OF THE CHARACTERISTICS OF FAST ACTING FUSES WITH BURNDOWN CHARACTERISTICS OF COVERED COPPER WIRE

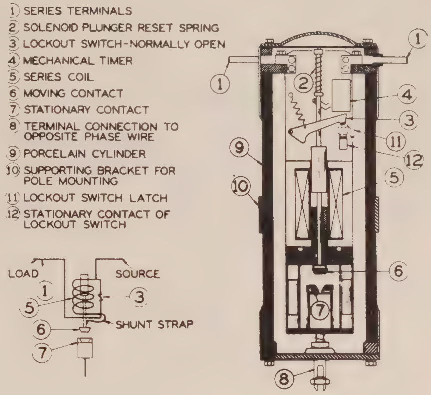


FIG. 3

CROSS-SECTIONAL VIEW OF SHORTING CONTACTOR

ventional automatic switchgear. It provides initial interruption of fault current within intervals down to ½ cycle. The second device is similar in design but incorporates a fast acting current interrupter, and is intended for use with circuits fused at the station bus. The third device is a fast opening and reclosing breaker incorporating all of the performance features of existing switchgear and capable of giving an initial opening in 2 cycles. The Shorting Contactor can be used with this device where the benefit of ½ cycle switching is desired.

Shorting Contactor

A cross sectional view of the Shorting Contactor is shown in Fig. 3. This unit is self-contained and fully automatic, requiring no auxiliary circuits or power supply. It is designed for pole or station mounting and can be either air- or oil-insulated. Being series operated, it is connected in one side of the circuit by means of terminals (1). A lead from the opposite side of the circuit is connected to the bottom terminal (8). It is intended that the station breaker working in the circuit with the Shorting Contactor will be arranged for "insantaneous" tripping for the initial opening, followed by "immediate" reclosure, and then the regular time-delay operation before lockout. The "instantaneous" tripping and "immediate" reclosure are not necessary but are desirable for the best circuit performance.

Normally contacts (6) and (7), Fig. 3, are open with full phase potential between them. Switch (3) is also normally open so that load current flows through solenoid coil (5). When a fault occurs, the flow of fault current through the solenoid causes the plunger to move downward closing contacts (6) and (7), and thus metallically short-circuiting the line directly through the lead connected to the bottom terminal. This metallic short circuit collapses voltage on the line and extinguishes the arc at the point

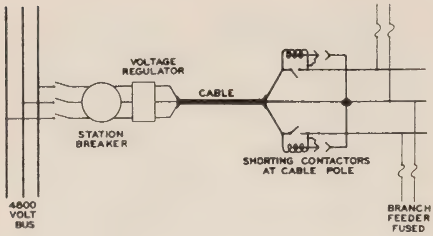


FIG. 4

APPLICATION OF SHORTING CONTACTORS TO CIRCUIT EQUIPPED WITH STATION SWITCHGEAR

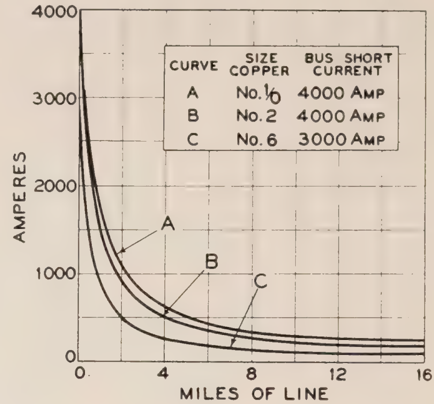


FIG. 5

DECREASE IN LINE SHORT CIRCUIT CURRENT WITH DISTANCE FROM BUS

of fault. The line voltage is held to zero as long as the contactor remains closed. Meanwhile, however, the station breaker trips and, if it is of the conventional type with "instantaneous" relaying, it will clear the metallic short from the system in about 10 cycles. Thereupon the contactor opens and lockout switch (3), controlled by mechanical timer (4), holds the device inoperative for an adjustable period to allow the station breaker to go through the usual reclosing cycles. After this interval, the lockout switch opens and the contactor automatically resets. For Detroit conditions, the contactor will be held inoperative for three minutes after each operation. It is evident that, if the device were not prevented from immediately repeating its operation should a fault persist, it would be impossible for the station breaker to successfully close into the fault and burn it clear, or blow fuses on the line.

Fig. 4 shows a typical application of Shorting Contactor to a circuit equipped with station switchgear. It will be noted that sectionalizing fuses are shown in the circuit. As will be seen later, the switching speeds of the devices described in this paper are such that fuses are protected from damage on the initial circuit interruption so that in case of transient faults the circuit is kept intact and service is restored to the entire line upon reclosure. In case of persistent faults, however, the fuses blow during the following time-delay operation of the breaker as intended.

It will also be noted in Fig. 4 that the Shorting Contactors are located at the cable pole. If they were located directly at the station, the line short circuit caused by the fault would be transformed into the equivalent of a metallic bus short which, on stations of comparatively large size, would cause undesirably heavy shock to the station equipment. This condition is avoided by locating the contactors a short distance out on the circuit from the station. For the case of overhead feed from the station, the effect of distance is shown in Fig. 5 where the steep impedance gradient near the station is set forth for typical circuits having different values of bus short circuit currents.

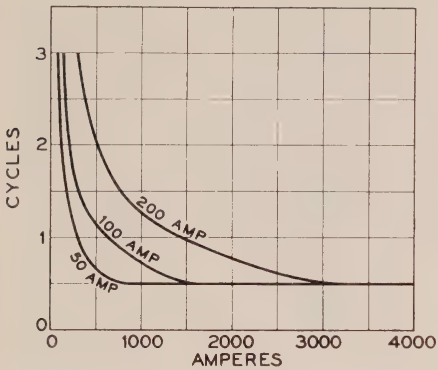


FIG 6
SWITCHING SPEED OF SHORTING CONTACTOR

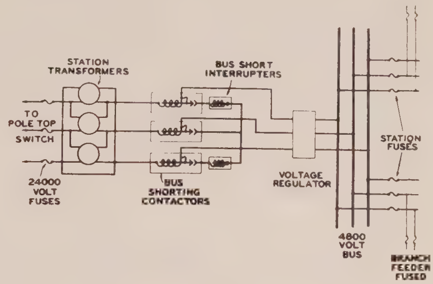


FIG 7
APPLICATION OF BUS SHORTING CONTACTORS WITH INTERRUPTERS TO SUBURBAN STATION WITH FUSED FEEDER CIRCUITS

The Shorting Contactor is designed to operate at current values 50 per cent over the normal rating of the main solenoid coil. Rated load currents can be carried continuously without exceeding normal temperature rise limits and sustained currents up to those required to cause operation can be carried continuously without damage to the equipment.

The curves of Fig. 6 show the switching speed of the Shorting Contactor with three different solenoid coils. It will be noted that all curves become flat at ½ cycle overall time. The performance of a single-phase circuit equipped with conventional switchgear and a Shorting Contactor is shown by the oscillograms of Exhibit B in the Appendix to this paper.

It might be mentioned that the principle of de-energizing a circuit by applying an artificial short circuit at the source is not new. It was suggested a number of years ago but as originally proposed there were no means by which operation within ½ cycle, and lockout within 4 cycles, could be accomplished. The self-contained, fully automatic ½-cycle device described herein is therefore new.

Shorting Contactor with Interrupter

The Shorting Contactor used in this scheme is essentially the same as the one just described, but the lockout switch is omitted. Fig. 7 shows an installation of this equipment from which it can be seen that the interrupter is connected in the short circuit lead from the contactor and carries no load current. The design principle of this interrupter was developed by The Detroit Edison Company a number of years ago. In normal operation the interrupter is in the closed position. When a fault occurs, the Shorting Contactor shorts the line through the interrupter. This causes collapse of bus voltage and extinction of any arc on the lines. Current through the interrupter causes it to open and lock out for a predetermined time. This removes the metallic short circuit and allows recovery of bus voltage. If the fault is transient, service is restored. If the fault persists, the Shorting Contactor is prevented from de-energizing the line again since the interrupter is locked in the open position. Fuses are then brought

into play and serve to clear the fault. Although the interrupter is capable of opening the artificial short circuit within one cycle, it is purposely delayed in this operation for six cycles to avoid re-establishment of the line arc by too rapid a recovery of line voltage.

This type of installation is particularly suited to stations where a large number of small conductors radiate from the bus and where the character of the load is such that more elaborate switchgear is not economically justifiable. Such stations are usually of sufficiently small capacity that applying the short circuit directly at the station bus is not objectionable. With high-speed switching there is no disadvantage in interrupting all lines connected to the bus to protect the one line, owing to the fact that the duration of the interruption is only six cycles, which is hardly perceptible to the customer.

Trial installations of this type, protecting four circuits, have been in service on The Detroit Edison system for one year and have given a perfect operating record.

Fast Opening and Reclosing Breaker

In the development of this equipment advantage was taken of the principle of current interruption incorporated in the interrupter described previously as having been developed by The Detroit Edison Company. This interrupter has proved itself capable of interrupting fault current consistently with not over ½ cycle arcing at the contacts and with exceptionally low arc energy, qualities essential in a breaker having overall interrupting time of the order here required.

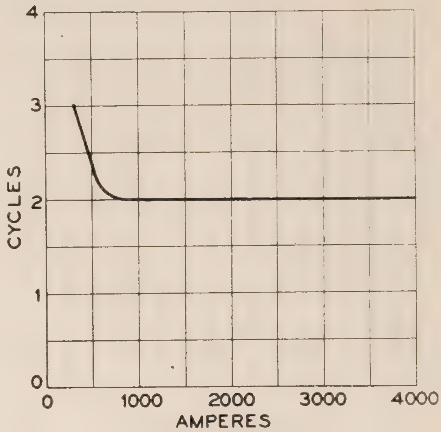


FIG. 8
SWITCHING SPEED OF FAST OPENING AND RECLOSING BREAKER

The equipment in its latest form is a single-pole oil circuit breaker, light in weight, self-contained and fully automatic, having its own mechanical timing mechanism. No auxiliary circuits or equipment are required for its operation. The control is arranged to give a fast initial opening followed by reclosure within any interval down to a few cycles, and a series of time-delay openings and reclosures before lockout. The speed of initial opening is shown in Fig. 8. Resetting from any point in the sequence of operation is automatic upon restoration of normal circuit conditions. For the present, a unit having a 250-ampere rating will be used. The minimum current to operate is adjustable to meet requirements of the circuit.

A diagrammatic view of the device is shown in Fig. 9. The coil of the control relay (4) is in series with the line. In normal operation the solenoid coil (6) is shunted through switch (5). When a fault occurs,

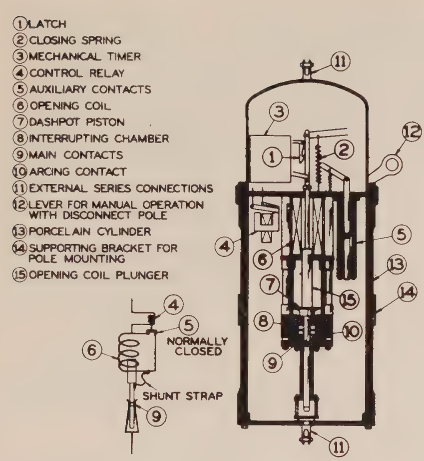


FIG. 9

CROSS-SECTIONAL VIEW OF FAST OPENING AND RECLOSING BREAKER

switch (5) opens and fault current flows through coil (6) which causes main contacts (9) to open. Energy stored in a spring during the opening stroke is used to reclose the breaker. The mechanical timer (3) serves to hold the breaker open for the desired interval before reclosure; it also serves to prevent the breaker from opening during the time-delay periods following initial opening. The timer consists of an escapement mechanism arranged in such a way that operating forces cause it to be driven forward to an eventual lockout position from which the breaker is prevented from closing. Short of this, the mechanism seeks to return to its normal reset position through a heavy clock spring which causes it to run in a reverse direction.

In one test of the breaker's interrupting performance it was put through a series of complete operating cycles to lockout at 5,000 volts on short circuits ranging from 1,000 to 4,000 amperes, the latter being the highest current which it is expected the breaker will be called upon to handle in the presently proposed application. The operating cycles included initial opening followed by three time-delay operations (4 openings in all) with ¾ of a second between reclosures. The time-delay intervals averaged about 1 second, varying inversely with current. The total number of circuit interruptions involved in the test was 72. A detailed inspection of the current interrupting parts at the end of the test showed that no replacement of parts was necessary and that the breaker was still in suitable condition for continued operation.

As to the maximum current that can be successfully interrupted without serious burning of contacts, tests thus far have been limited by the capacity of the test facilities, but several interruptions of 7,000 amperes at 5,000 volts do not make replacement of parts necessary.

The breaker in its present form differs from any single-pole circuit interrupter with which the author is familiar in that it provides for time-delay operations in addition to its fast initial opening. It has load-current and interrupting ratings which put it in the class of a station breaker suitable for fairly heavy circuits.

According to present plans, the newly developed breaker will find its initial application on both new and existing fused suburban and rural circuits. Fig. 10 shows a proposed typical application. Past practice has been to connect many of these circuits directly to the station bus through

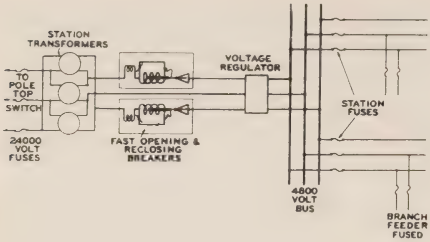


FIG. 10

APPLICATION OF FAST OPENING & RECLOSING BREAKERS TO LIGHT CAPACITY FEEDER CIRCUITS

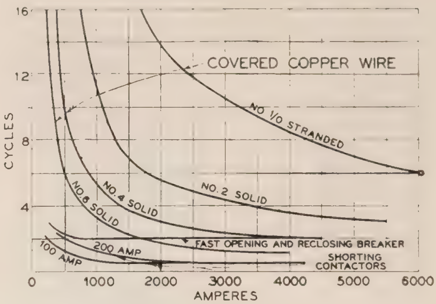


FIG. 12

BURNDOWN CHARACTERISTICS OF COVERED COPPER WIRE COMPARED WITH SWITCHING SPEEDS OF NEW DEVICES

fuses. The new breaker, in addition to giving protection against primary line burndown on transient faults by its 2-cycle initial opening, will add to these circuits all of the operating advantages and features of fully automatic switchgear. When faster initial opening is required to assure against burndown of No. 6 or No. 4 covered conductors, the Shorting Contactor can be used in conjunction with this new breaker. An arrangement of this sort is shown in Fig. 11. In this case the Shorting Contactor will extinguish the arc in ½-cycle and the breaker will clear the short from the system in 2 cycles. The breaker will be adjusted to reclose in about 30 to 45 cycles whether used alone or with Shorting Contactors. Oscillograms showing the performance of the breaker alone, and operating with the Shorting Contactor, are included as Exhibits C and D in the Appendix.

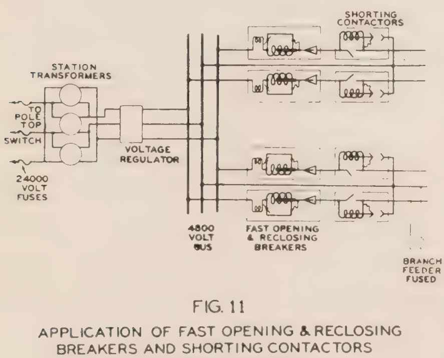


FIG. 11

APPLICATION OF FAST OPENING & RECLOSING BREAKERS AND SHORTING CONTACTORS TO SUBURBAN CIRCUITS

Exhibits E and F, in the Appendix, show the appearance of arc burns of ½-cycle duration on No. 6, No. 4 and No. 2 covered conductors, and also a 2-cycle arc burn on No. 2 conductor. The No. 6 conductor with ½-cycle, 1,500-ampere arc burn still retains 80 per cent of its original strength and the No. 2 conductor with the 2-cycle, 1,500 ampere arc burn retains 75 per cent of its original strength. In Fig. 12 the burndown curves for covered copper wire, shown previously, are repeated together with the switching speeds of the 100- and 200-ampere Shorting Contactor, and the fast opening breaker. This serves to show the margin of safety between the overall arcing time allowed by the different devices and the critical arcing time for the various sizes of conductor.

Exhibit G of the Appendix shows the diagram of circuits connected to Inkster Substation of The Detroit Edison Company which is now being equipped with fast opening and re-

closing breakers. Shorting Contactors are being installed in the circuits as indicated. The diagram shows the location of fuses in the circuits and also the size, type, and mileage of conductors. The short circuit currents indicated at the locations of Shorting Contactors show the effect of line impedance in reducing the magnitude of the metallic short circuits to be applied by the contactors, the value of short circuit current at the bus being 4,000 amperes, three phase.

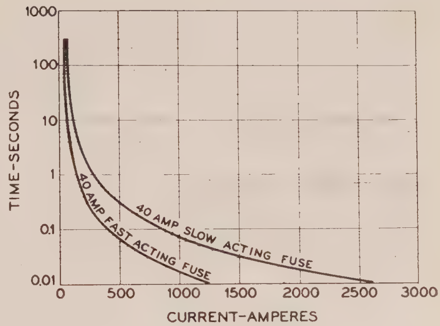


FIG. 13

CHARACTERISTICS OF 40 AMPERE SLOW ACTING AND FAST ACTING FUSES

FUSES

As indicated earlier, an added advantage of fast initial fault current interruption of the order here discussed is the fact that sectionalizing fuses are saved from damage by the first opening, and if the fault is of transient nature, service is restored to the entire line upon reclosure. If the fault persists, however, the fuses are blown on the following time-delay operation of the breaker as intended. Heretofor, The Detroit Edison Company has used sectionalizing fuses sparingly (almost none) because experience has shown that with existing switchgear the use of fuses involves more outage than that attendant on operation without them. This is because they blow on transient faults.

With the new switching practice, the objection to the use of fuses in the circuit is removed. It should be noted that, whereas in past practice fuses have constituted what might be called a first line of defense, in the new practice they are relegated to a position of secondary defense, for the switching equipment is to be given the first opportunity to deal with the trouble. Under these conditions it is evident that the fuses shall blow only on the time-delay operations subsequent to the initial opening. Progress made in the development of fuses with slow acting characteristics is shown in Fig. 13 where the curves for 40-ampere fuses of both the fast-acting and the slow-acting type are compared. Similar differences exist in other ratings. It can be seen that for a given time to blow, the current carried by the slow-acting fuse is much greater than that carried by the fast-acting fuse. This means that the slow-acting type can be installed at points in the circuits much closer to the station, where fault currents are higher, than is possible with the fast-acting type. In other words, the limits previously imposed upon the location of fuses are now greatly widened.

The co-ordination between the characteristics of slow-acting fuses and switching speeds of the newly developed equipment, already described, is shown in Fig. 14.

As a matter of general interest, Exhibit H is included in the Appendix to show the extent of damage to overhead conductors of different sizes

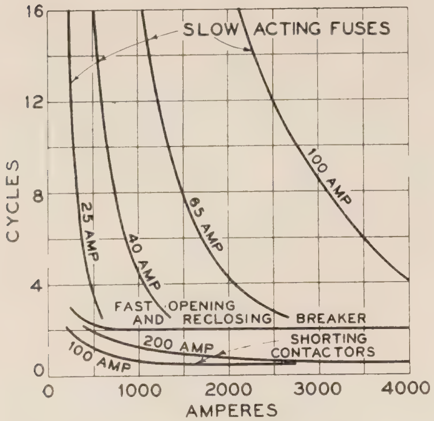


FIG. 14

CHARACTERISTICS OF SLOW ACTING FUSES COMPARED WITH SWITCHING SPEEDS OF NEW DEVICES

when exposed to 1,500 ampere arcs of the durations indicated. Exhibits I, J and K show the result of arcing faults under the conditions stated thereon.

SUMMARY

Summarizing, there are six points that I want to mention:

1. Switching to clear faults within an overall time interval ranging from ½ to 2 cycles (1/120 to 1/30 second) will reduce the number of falling wires caused by transient faults.

2. Fewer wires down will reduce the outages and improve the service.

3. Single-phase switching will reduce outage.

4. Sectionalizing can be increased to advantage by fusing more extensively because the sections will not be cut off by transient faults.

5. The switchgear necessary for ½ cycle fault switching is inexpensive.

6. A workman who accidentally creates an arcing fault is less liable to serious injury with ½ cycle switching than he is with 10 to 40 cycle switching.

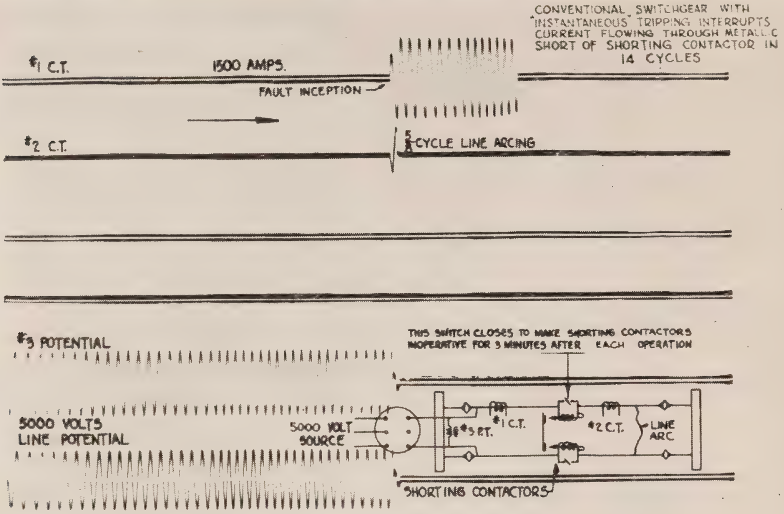
APPENDIX

EXHIBIT "A"

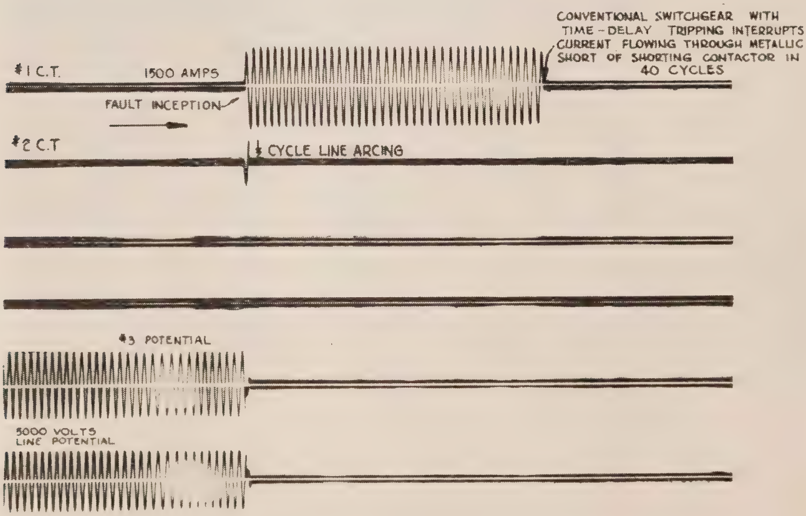
Cases of Trouble on the Distribution System Involving Primary Wires Down

Month	1938			1939		
	Total No. of Cases	No. of Cases Attributable to Lightning and Wind	No. of Electrical Storms	Total No. of Cases	No. of Cases Attributable to Lightning and Wind	No. of Electrical Storms
January	15	0	0	18	0	0
February	37	24	4	23	1	1
March	40	22	4	328 Sleet storm	1	0
April	56	22	2	22	0	1
May	40	17	6	48	21	4
June	109	57	6	277	158	6
July	165	111	7	98	68	7
August	155	89	5	45	15	7
September	21	2	1	88	50	5
October	26	3	3	26	6	2
November	16	0	0	12	0	0
December	23	1	1	8	0	0
Total	703	348		993	320	

EXHIBIT "B"

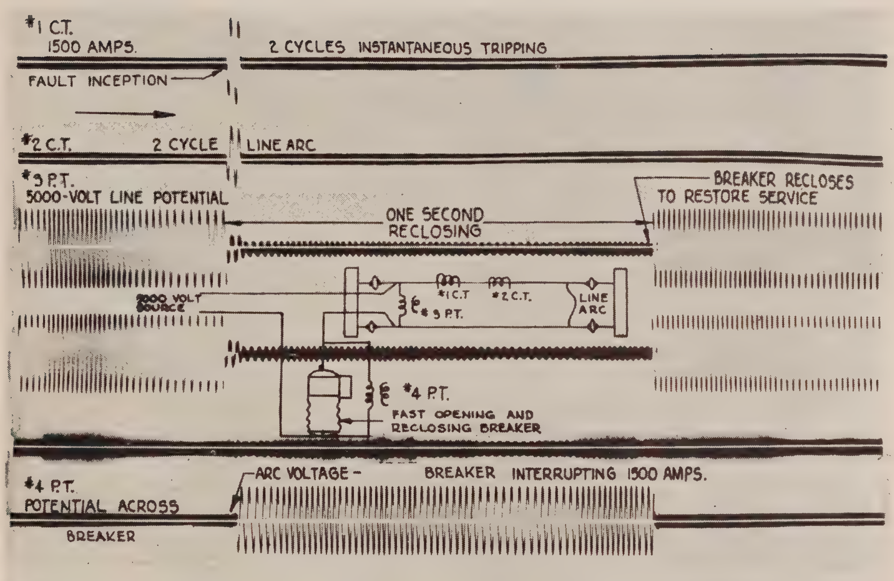


PERFORMANCE OF CIRCUIT WITH SHORTING CONTACTORS OPERATING WITH CONVENTIONAL SWITCHGEAR; "INSTANTANEOUS" TRIPPING—TRANSIENT FAULT CLEARED IN 5/8 CYCLE



PERFORMANCE OF CIRCUIT WITH SHORTING CONTACTORS OPERATING WITH CONVENTIONAL SWITCHGEAR; TIME-DELAY TRIPPING; TRANSIENT FAULT CLEAR IN ½ CYCLE

EXHIBIT "C"



PERFORMANCE OF CIRCUIT WITH FAST OPENING AND RECLOSING BREAKER OPERATING TO CLEAR A TRANSIENT FAULT IN 2 CYCLES AND RESTORING SERVICE IN ONE SECOND

EXHIBIT "D"

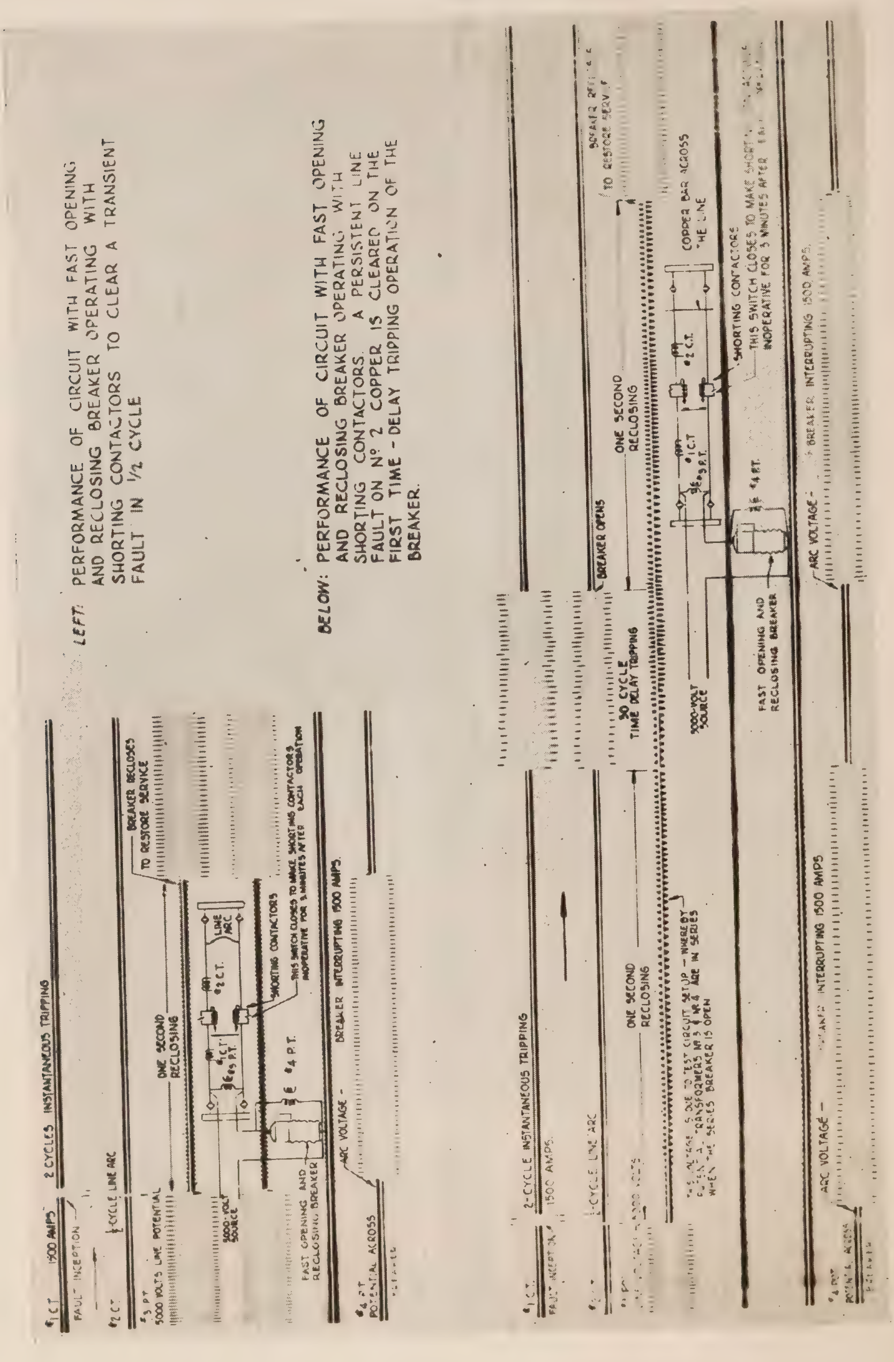

LEFT: PERFORMANCE OF CIRCUIT WITH FAST OPENING AND RECLOSING BREAKER OPERATING WITH SHORTING CONTACTORS TO CLEAR A TRANSIENT FAULT IN 1/2 CYCLE
BELOW: PERFORMANCE OF CIRCUIT WITH FAST OPENING AND RECLOSING BREAKER OPERATING WITH SHORTING CONTACTORS. A PERSISTENT LINE FAULT ON Nº 2 COPPER IS CLEARED ON THE FIRST TIME - DELAY TRIPPING OPERATION OF THE BREAKER.
2 CYCLES INSTANTANEOUS TRIPPING
1500 AMPS
FAULT INCEPTION
ONE SECOND RECLOSING
BREAKER RECLOSES TO RESTORE SERVICE
5000 VOLTS LINE POTENTIAL
5000-VOLT SOURCE
SHORTING CONTACTORS
FAST OPENING AND RECLOSING BREAKER
ARC VOLTAGE
BREAKER INTERRUPTING 1500 AMPS
2-CYCLE INSTANTANEOUS TRIPPING
BREAKER OPENS
30 CYCLE TIME DELAY TRIPPING
COPPER BAR ACROSS THE LINE
THIS SWITCH CLOSES TO MAKE SHORT AND IS INOPERATIVE FOR 3 MINUTES AFTER EACH OPERATION

EXHIBIT "E"

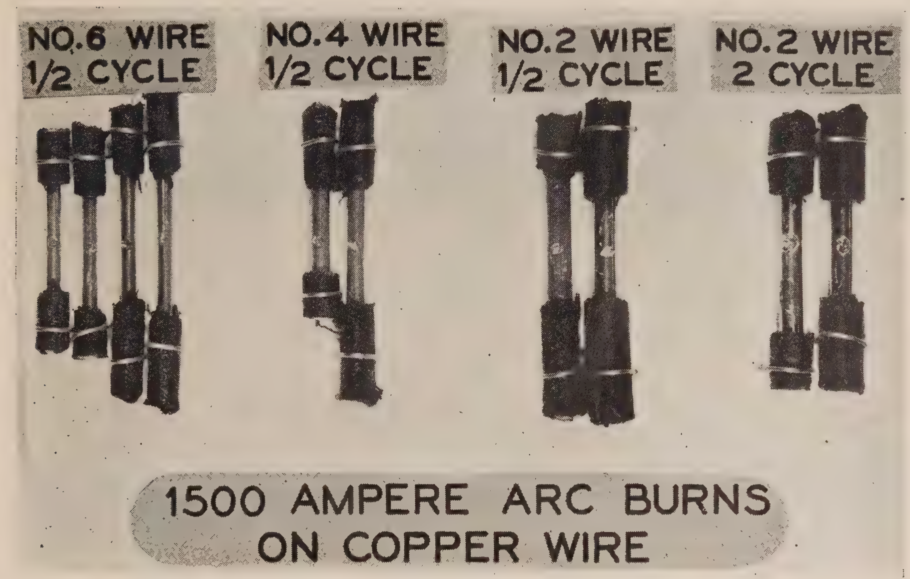


EXHIBIT "F"

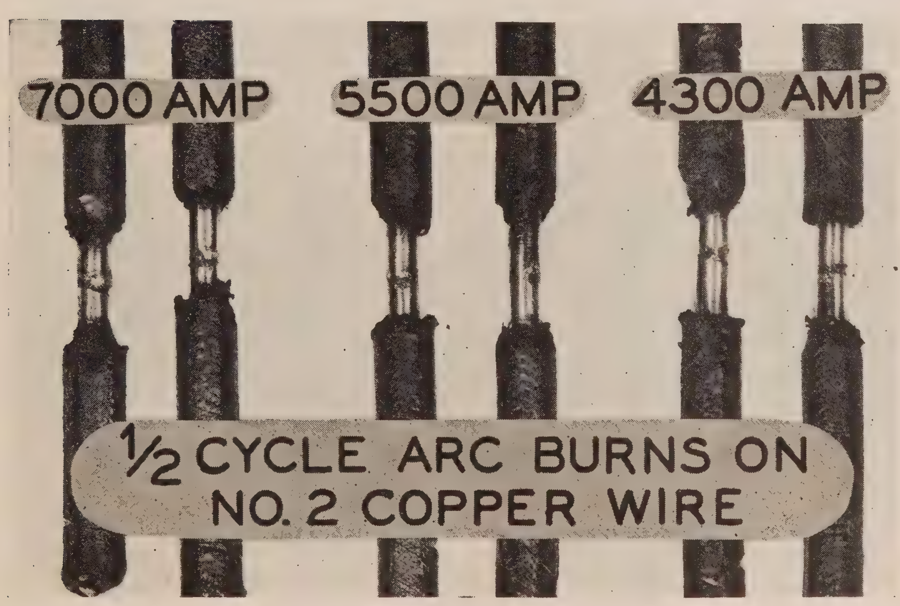
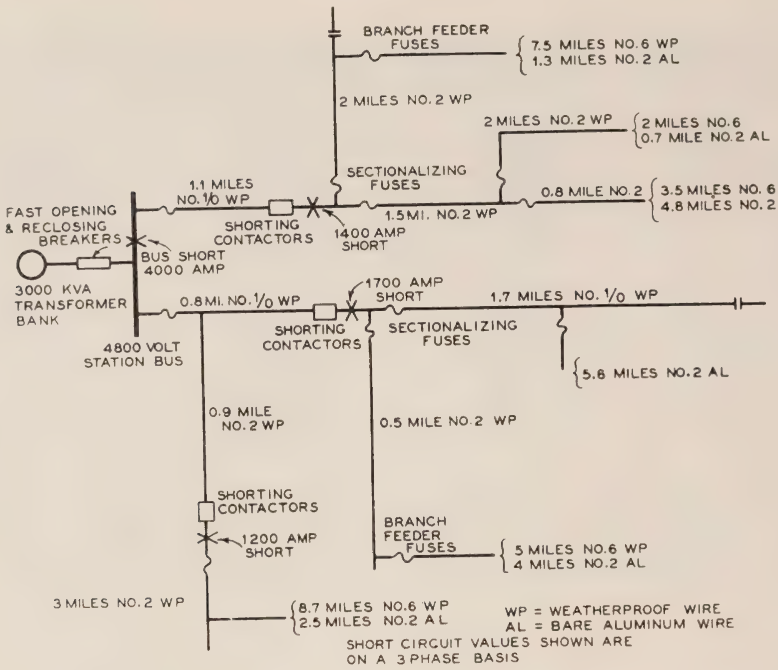
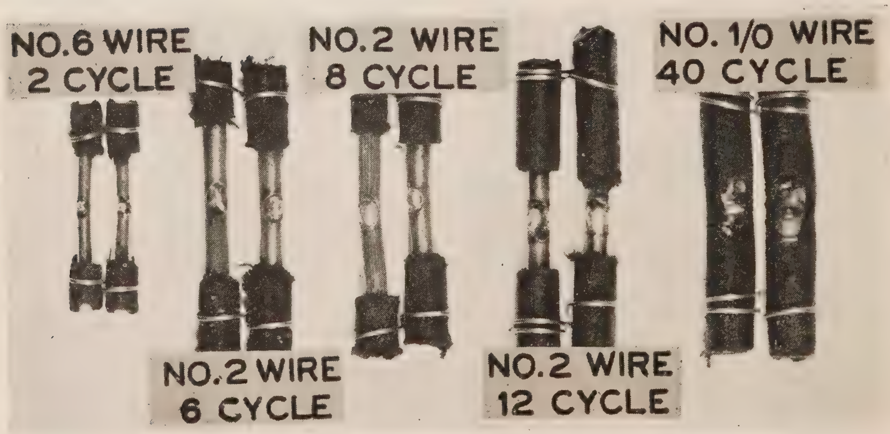


EXHIBIT "G"



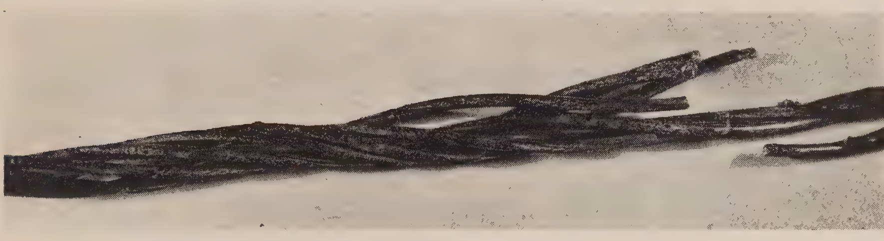
Installation of Fast Opening and Reclosing Breakers with Shorting Contactors at Inkster substation.

EXHIBIT "H"



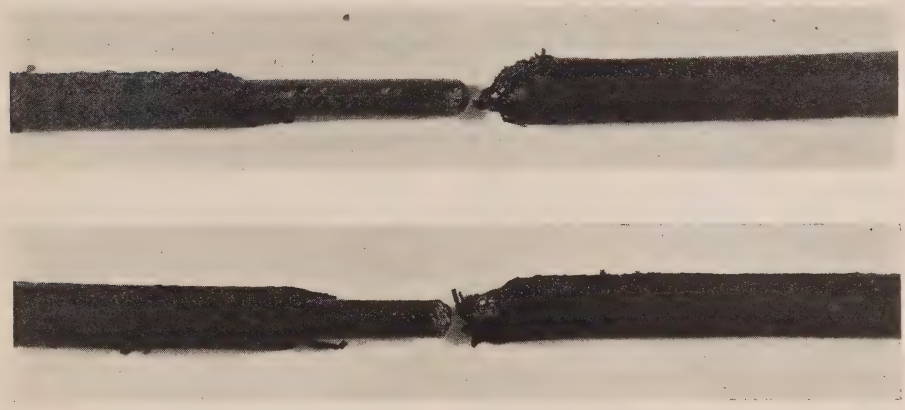
1500 ampere arc burns on copper wire not under tension during test.

EXHIBIT "I"



*No. 2 a.c.s.r. conductor after 200 ampere tree-limb fault.
Tree limb burned clear.*

EXHIBIT "J"



No. 2 covered copper conductor after 900 ampere, 11 cycle arcing fault.

EXHIBIT "K"

No. 0000 covered copper conductor after 3,000 ampere, 12 cycle arcing fault.

(This paper was presented to the Association of Municipal Electrical Utilities at Toronto on February 5th, 1941.)

Drainage Pump

Modern Unit Replaces Bucket-Wheel Type in Dover Township

By W. G. McGeorge, Chatham

THE recent installation of a new drainage pump in the Township of Dover (Kent County, Ont.) may be of some interest because of its being a departure from the kind of installation which has been common in that particular section of Ontario.

In the township there are comparatively large areas of land which are so low, as compared with lake level, that they cannot be successfully drained by gravitation, with the result that recourse has been had to banking and pumping to provide the necessary drainage.

In this and adjacent townships, there are at least twenty-five different drainage schemes of this kind, all constructed and operated under the provisions of the Municipal Drainage Act, and ranging in size from two or three hundred acres up to almost six thousand acres.

From an engineering standpoint, the problems to be solved in these schemes are the segregation of the low lands from the higher lands, the construction of necessary banks to protect the areas to be drained from outside water, and the provision of sufficient reservoir capacity and pumping capacity to ensure proper drainage.

STEAM-DRIVEN SCOOP WHEELS

The inauguration of these pumping schemes goes back at least fifty years, and the most common form of pump used has been the steam-driven dash or scoop wheel. These wheels were from eighteen to thirty feet in diameter, fitted with arms or scoops, and, operating in wheelpits or channels, scooped the water out of the reservoirs and discharged it into the outlet channels. They were operated at slow speed, were simple in construction, could be operated by almost anyone, and, under certain conditions of water levels, were reasonably efficient. Some other types of pumps were also used, such as scroll pumps, Chinese pumps, and a few centrifugal pumps, but the dash-wheel was the predominant type in use for many years, and, where the lifts were low and fuel and labor costs for generating steam were also low, these pumps met the needs fairly well.

MULTIPLE UNITS NEEDED

With the gradual passing of steam power and the introduction of gasoline and electric motors, the need for a more efficient type of pumping plant became apparent. Where electric power has been used to operate dash-wheels, motors of comparatively large horsepower have been required

to meet the extreme demands. The solution would seem to lie, generally, in the installation of multiple units of efficient pumps operating with motors of low horsepower, some of which may be used only in times of extreme demands.

In the particular scheme to which reference is made in this article (which is known as the Whitebread Pumping Works), the area to be drained consisted of about eighteen hundred acres of land, ranging in elevation from slightly below to slightly above lake level. The scheme was inaugurated about twenty-five years ago, a steam-driven dash-wheel being installed to do the pumping. The reservoir capacity in this particular scheme is exceptionally large, there being seven or eight miles of large dredge-cuts, and the lands have been well drained. The pump discharges the water into the river Chenal Ecarte, which generally is almost at lake level.

A few years ago, the steam engine being in a bad state of repair, a 40-h.p. electric motor was installed to operate the wheel, and the plant has operated successfully with this power. The wheel, being beyond repair, the installation of a new pump became imperative.

The new pumping unit was selected after a thorough investigation of various available types of pumps and drives. The main consideration was that of obtaining the greatest possible volume of water from a pump driven by a 25-h.p. motor; in other words, the highest possible efficiency not only during the initial period of operation but also a reasonable assurance of sustained efficiency during many years of operation.

Other important considerations were those of simplicity in design, necessary to obtain low cost of attendance as well as low cost of the new supporting structure; also rugged construction, to insure the lowest possible cost of maintenance and repairs; and last, but not least, a long and successful experience on the part of the pump manufacturer in the design and manufacture of units for this or similar type of service.

This type of pump develops the pumping action predominantly by an axial propulsion of the water, in a manner quite similar to the "propelling" of a ship through water. Its propeller is mounted on a vertical shaft and is located in the submerged pump bowls; this entirely eliminates all necessity for priming equipment and separate priming operation before starting the pump.

The open propeller design used in this pump eliminates the use of close-fitting metal seals, usually known as "wearing rings". These are practically always found in the design of centrifugal pumps, and they must be maintained (by replacement) to original clearances in order to obtain sustained pumping efficiency. Since wearing rings are eliminated from the propeller-pump design, this type of pump has been found capable of handling water containing a considerable amount of sand and silt without noticeable depreciation in efficiency.

The entire pump is suspended from the discharge-elbow base-plate that rests on the pump-house floor. This

base-plate, the tapered discharge column below the floor, and the discharge elbow, are all fabricated as one unit from rolled steel plate welded together into a rigid assembly. An extension on top of the elbow carries the vertical motor drive.

A hand-hole with bolted cover has been provided in the elbow immediately above the base-plate, through which a steam connection can be lowered into the pump-bowl assembly whenever it becomes necessary to start pumping operations while the water is covered with heavy ice. The steam, which will be generated in a small wood-fired boiler, will be used for thawing out the ice from inside the pump-bowl before the pump is started.

The pump is driven by a 25-h.p. motor at 720 r.p.m., operated on a 3-phase, 25-cycle, 550-volt circuit. It is a vertical hollow shaft motor, of drip-proof and weather-proof construction. A common thrust-bearing, located in the top of the motor, carries the combined weight of rotor, pump-shaft and propeller, and the hydraulic thrust.

The pump discharges through a 30-in. discharge pipe fabricated from corrugated steel sheet and fitted on the outer end with a flap valve to prevent backflow of water through the pump during abnormally high river-stages. For normal high river-stage the bottom of the pump-discharge elbow is 6 in. above the river level.

The normal maximum difference between the level of the suction water in the drainage ditch and the level in the river is six feet.

The pump is designed to deliver 8,250 Imperial gallons per minute against a total head of 7.75 ft., corresponding to a pool-to-pool difference of 6 ft. The power consumption for lifting one million Imperial gallons of water per foot lift is 5.29 kw-hr., based on a pool-to-pool head of 6 ft.—*Water and Sewage.*

Cameron Falls generating station, Nipigon river.

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Aylmer Street Lighting

By Geo. G. Cousins, Supervising Lighting Engineer,
H.E.P.C. of Ontario

TO many of the generation that is now approaching maturity a horse and buggy is almost as much of an oddity as a yoke of oxen is to their grandparents. They definitely belong to a by-gone age, an age of slow motion, oil lamps, washboards, and the family album. The dusty, slow, rough-riding buggy has given way to the smooth-riding, comfortable, heated (in winter) motor car that can travel as far in an hour as the horse and buggy could go in a day. There are dozens of fast moving motor cars today to one horse and buggy of a couple of decades ago. Yet, with a few exceptions, the street lighting of today belongs to the conditions of the horse and buggy days as far as its revealing power is concerned. The terrible loss of human life, from traffic accidents, of to-day is the natural result of this failure of the protective agencies to keep pace with the destructive ones. Any normally active person can avoid a horse drawn vehicle except under extraordinary circumstances, but is no match for the speed of approach of automobiles under quite common conditions of traffic.

Statistics have shown that about two-thirds of the daily accidents occur during hours of darkness when the number of vehicles on the roads is about one-third of the daily total. The only fundamental difference between day and night conditions is the very low visibility of objects or persons at night as compared to that of daylight hours. Consequently, the remedy is to apply illumination in such a way that motor vehicle drivers can see pedestrians or obstacles in time to avoid striking them.

Effective illumination is the one and only means of making any appreciable reduction in night traffic accidents. The lighting units must be so designed and so located that the roadway is effectively illuminated; otherwise, a lot of money may be spent for a very small improvement over former conditions.

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Vol. XXVIII **No. 3**

March, 1941

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

The new lighting on Talbot Street, Aylmer, embodies in its design the latest knowledge of the subject, and utilizes equipment of the most modern design combining good light distribution and high efficiency. The lighting units are placed over the pavement in which location they provide a high degree of effectiveness in revealing pedestrians as they cross the street or any other objects that may endanger life. In addition to the safety requirements, the attraction value of a well-lighted business section is a decided asset to the merchants of the town.

A feature of this installation that is worthy of mention is the removal of the poles from the street. This greatly improves the appearance of the street and the width is apparently much greater than before. The brackets upon which the units are mounted are fastened to the walls of the buildings. The units are arranged in a staggered system with a spacing of about 67 feet measured along the centre of the street; the height is 22 feet above the pavement, and they are suspended 2 feet beyond the curb. The lamps are of 500 watt size. The average illumination on the pavement is .9 foot-candles,—the maximum, 1.6 ft-c. and the minimum, .5 ft-c. These

Lighting on Talbot street, Aylmer, Ont.

intensities exceed the minimum values recommended by the Illuminating Engineering Society and rank with the illumination on the business streets of many of America's important cities. The measurements of illumination intensity were made with an optical photometer with a test plate specially suited to street lighting measurements.

The Lighting Service Section of the Commission had the pleasure of collaborating with Stuart McBrien, superintendent of Aylmer Public Utilities Commission, in the design of the system.

Draughting Room Lighting

By C. B. Stephens, Assistant Engineer, Electrical Engineering Department, H.E.P.C. of Ontario

SATISFACTORY lighting of a draughting room has long been desired and as each new step in the lighting art is taken the ultimate goal is that much nearer. Not so many years ago daylight through windows afforded the best known lighting. But that was not available on dark days nor at night. Then came the gooseneck table lamp of the articulated tubing variety, employing the carbon lamp or 60 watt tungsten. Next came the general overhead lighting to supplement or supersede the table lamp. Then the general acceptance of the indirect lighting designs with higher and higher wattages came into its own.

But there were grievances, ceilings appeared too bright. Work spaces became too hot, on account of the high wattage of the lamps. These grievances have to a great extent been overcome by coffers, deeply beamed ceilings and by ventillating systems.

Now the fluorescent lamp is here, along with a brand new set of application problems. This lamp fills a long felt need because it embodies low brightness, high efficiency, low operating temperature and colours that will supplement daylight.

Lamps and Auxiliaries

The fluorescent lamp in greatest demand at present is the 40 watt, 48 inch T12 type F lamp in white or daylight colour. There is, however, a growing demand for the 85 watt type RF lamp and the newer 100 watt, 60 inch T17 type F lamp. A complete line of auxiliaries for all the lamp sizes is available for 60 cycles at standard voltages.

So far the only 25 cycle auxiliary is the 40 watt "tulamp" high power factor unit for use on 110-125 volts. This auxiliary operates at about 95 per cent power factor, draws 0.85 amperes, and consumes about 101 watts at 118 volts.

As the name "tulamp" implies, two 40 watt lamps are supplied from it, one at a lagging power-factor through

A paper presented at the First Canadian Regional Conference of the Illuminating Engineering Society, Toronto, March 19th, 1941.

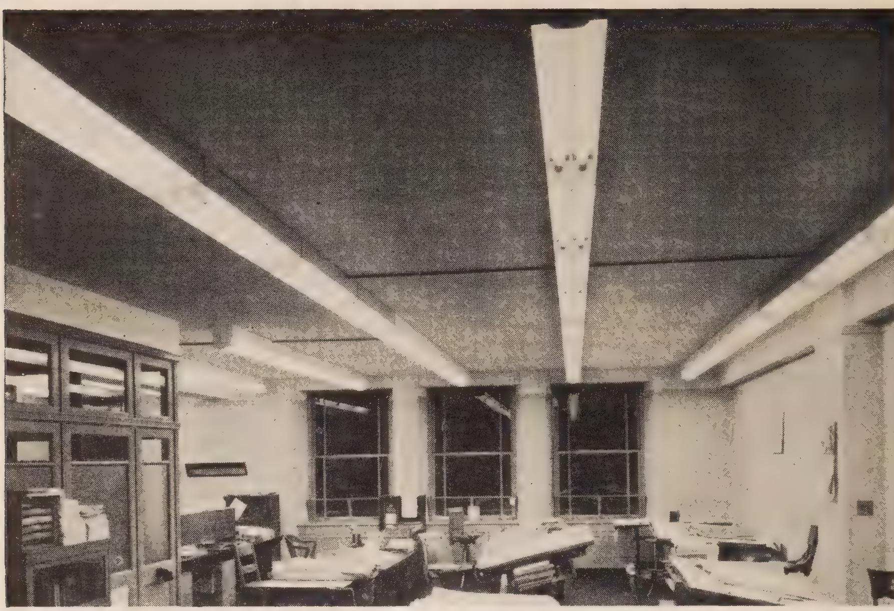


Fig. 1—One corner of a draughting room showing eight luminaires end to end, each luminaire contains two 40 watt fluorescent lamps.

a reactor, the other at a leading power-factor through a capacitor and reactor. An auto-transformer in the "tulamp" steps up the supply voltage to suit the reactor and lamp requirements.

Experiments with 3-Phase Supply

In considering fluorescent lighting for the draughting rooms in the Administration Building of The Hydro-Electric Power Commission of Ontario, estimates were made on a 60 cycle and on a 25 cycle design, the latter indicating a substantial reduction in cost, since no frequency changers nor separate 60 cycle distribution would be required.

Accordingly two luminaires for six 40 watt lamps were purchased and each equipped with three "tulamp" 25 cycle auxiliaries and arranged for 3-phase, 4 wire supply. In use, the lighting effect was very good as there was no noticeable flicker on the working plane. Here it should be noted, that on a single lamp there are two pulsations of light per cycle—one per alternation of the voltage wave. On a "tulamp" group there are four light pulsations per cycle, since the capacitor referred to previously introduces a phase displacement of 115° in the time of flash of the two lamps referred to the same voltage wave. Therefore, with 6 lamps on three phase there are 12 light pulsations per cycle, or 300 per second.

The experiment proved the theory that the lighting effect on 3-phase would be satisfactory. It, therefore, seemed feasible that a number of luminaires designed for two lamps could be used in a room and if con-

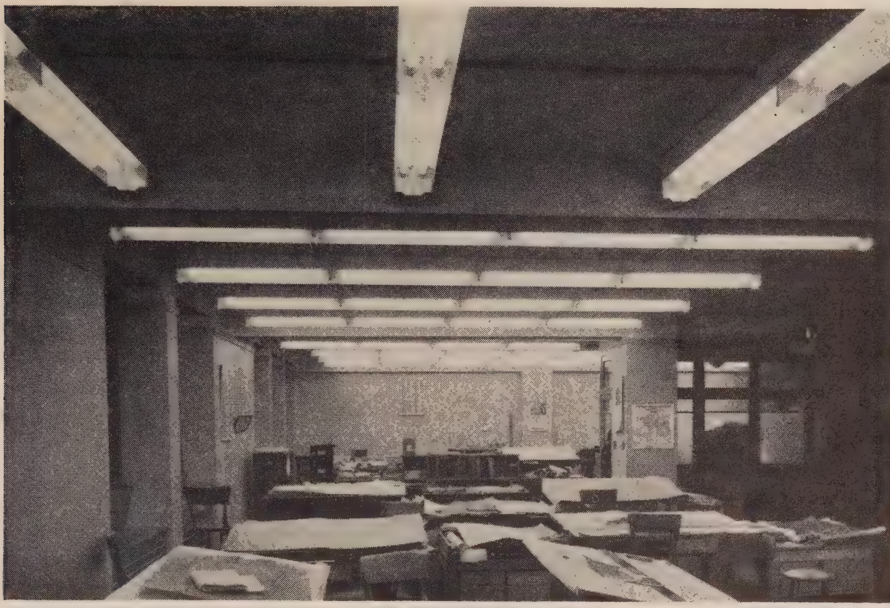


Fig. 2—Another view of part of the same room as in Fig. 1, showing different grouping of luminaires and interconnecting wiremold.

nected to a 3-phase supply the resulting illumination on the working plane would be as good as that from the 6 lamp luminaires.

A Trial Installation

Accordingly, certain suggestions were offered regarding the design of a two lamp luminaire. Soon a satisfactory unit was produced which afforded co-operation between the two lamps as regards flicker effect. An order was then placed for twelve such units and upon delivery were installed in an inside bay in one of the draughting rooms. There were three rows of four units end to end with a spacing of 5 feet 3 inches on centres between rows, for a finished grouping of 5 rows in the wide bay.

This installation on a 3-phase supply was entirely free from flicker on the working plane and on the ceiling. The question was later asked what the effect would be if operated on a single phase supply. This was done one afternoon but everyone was glad when the supply was changed back to 3-phase.

The required quantity of two lamp luminaires were purchased after having issued specifications and inviting tenders.

Installation and Control

In general all branch circuits in the Administration Building are 3-phase, 4 wire, so it was a simple matter to revise the lighting layout drawings to accommodate the fluorescent scheme.

The depth of bays permitted the use of four luminaires end to end, while the bay widths permitted nearly

uniform spacing of the rows at a little over 5 feet. The total range of spacing was 4 feet 6 inches to 5 feet 7 inches.

The luminaires in one or two bays, depending on the room arrangement, are controlled from one switch location, either by three existing single pole switches or by one single pole switch plus a two pole contactor located in one of the luminaires. Conduit wiring above the ceiling is led into a luminaire directly if it is located below an outlet or by wiremould and a box extension from an outlet where the 3 phases are available. Connections between rows of units are also in wiremould. All knockouts in the luminaires were factory punched and located 7½ inches from one end only, and this location satisfied all assembly combinations.

Ample space is provided in the luminaires and in the end closures for circuit wires when units are assembled end to end. Each unit is attached to the suspended metal lath and plaster ceiling by two one-quarter inch toggle bolts, holes for which are provided near each end of the unit.

The correct mixing of the phases is best effected by taking them in order along one row of units and starting the next row with another phase and so on to the end of the switching group. This rotation is continued without interruption in starting an adjacent switching group, in order to avoid the possibility of two rows with the same phases opposite each other.

Illumination Levels

Foot candle readings on the horizontal plane at draughting table level have been taken at night. These readings range from 40 at the margin of the working areas to 65 over the greater part of the working area, and to a maximum of 75. These values may be considered as partly depreciated as the lamps have been burned over 100 hours, the period during which the lamps emit more than the rated lumen output.

Comments

When this lighting is used at night there are shadows in the wrong direction on all the tables near the outside walls and windows as the source of light is above and to the right of these tables. In daytime this condition does not exist. The second row of tables, however, never has adequate daylight and the source of light for these is above and to the left.

There has been some discussion about having the lines of fluorescent light at a horizontal angle of about 45° with the outside wall to improve the shadow condition. During the period of trial, tables were used in all directions but were finally moved back to being parallel with the rows of luminaires.

The "white" fluorescent light seems to blend with daylight so well, the daylight appears to reach right across the room. There is no objectionable colour clash as with incandescent light and daylight. The lamps have coated ends to conceal the pronounced flicker at the electrodes.

Utility Transportation

By H. D. Rothwell, Assistant Engineer, Municipal Engineering Department, and Chairman of the Truck Committee, H.E.P.C. of Ontario

ONE of the most important tools used in the construction and operation of a large public utility is mechanical transportation of both men and materials. The vast areas and distances covered make it necessary that the work undertaken be done in a minimum time with a maximum efficiency in order that the best service to the public may be rendered at the least cost.

In order to visualize the importance of transportation as far as The Hydro-Electric Power Commission of Ontario is concerned, it is interesting to note that at the present time approximately 350 trucks of various sizes and types are required for operation and construction purposes. In 1940 these trucks travelled approximately 3,623,000 miles.

Since the inception of the Commission, the matter of mechanical transportation has been largely the facilities offered by the motor car manufacturers in the way of trucks and cars supplied to general commerce throughout Canada, but in recent years some special types of vehicles have been produced which more nearly fulfill the requirements of the work to be performed.

Past experience has shown that very few, if any, of the trucks produced by the manufacturers were suitable in the form received for the general work of the Commission, with the result that as soon as they were turned over to the operating or construction staffs, attempts were made to reconstruct the vehicles in a fashion more suitable for their particular needs. A survey of this reconstruction over a period of years has revealed many novel and practical ideas, as well as some which were quite fantastic. A study of these has brought out the fact that the trucks supplied did not wholly meet the requirments of the workmen in the field, with the inevitable result that most engineers who had to do with ordering new vehicles, usually tried to incorporate some of their personal designs or those of the field staff, in the new trucks, in an attempt to produce something more suitable for the work to be undertaken.

A survey of the Commission's truck fleet made some years ago indicated the fact that approximately twenty different designs embodying individualistic ideas of the various sections of the Commission, were in use. Many of these ideas were excellent, but no one vehicle was suffi-

Paper presented to the Ontario Municipal Electric Association and the Association of Municipal Electrical Utilities at Toronto, February 5, 1941.

Fig. 1—The above illustrates the type of winch and derrick equipment being supplied to the larger rural districts operated by the Hydro-Electric Power Commission. This equipment will handle 25 to 40-foot poles.

cient to be adopted as a standard for the Commission's work.

Until approximately three years ago, each department ordered transportation equipment necessary for the work to be undertaken, without reference to any other department. In order that there might be some standardization and uniformity, the Commission therefore appointed a committee of engineers to act in an advisory capacity to the various departments, for the purpose of selecting truck designs, as well as to assist in the purchase, operation and maintenance of the whole truck fleet, and especially to reduce the number of types of vehicles in use.

When this committee was first formed, as previously stated, at least twenty different designs of truck bodies were used by the various departments. After considerable study, it was felt many of these designs could be dispensed with and a minimum of not more than six or seven different types could be selected for the work undertaken by the Commission. Studies were also made with the object of determining whether each particular type of vehicle was the most suitable for the work being done, that

Winch equipment in truck shown in Fig. 1.

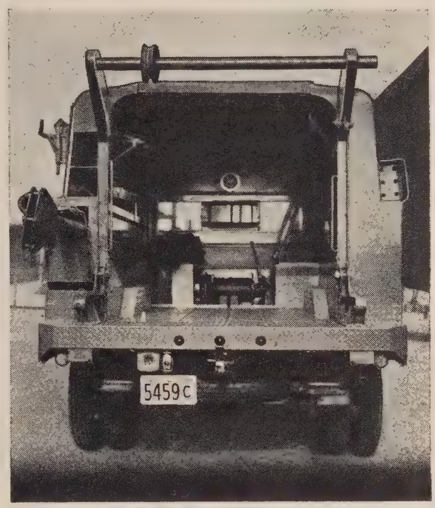


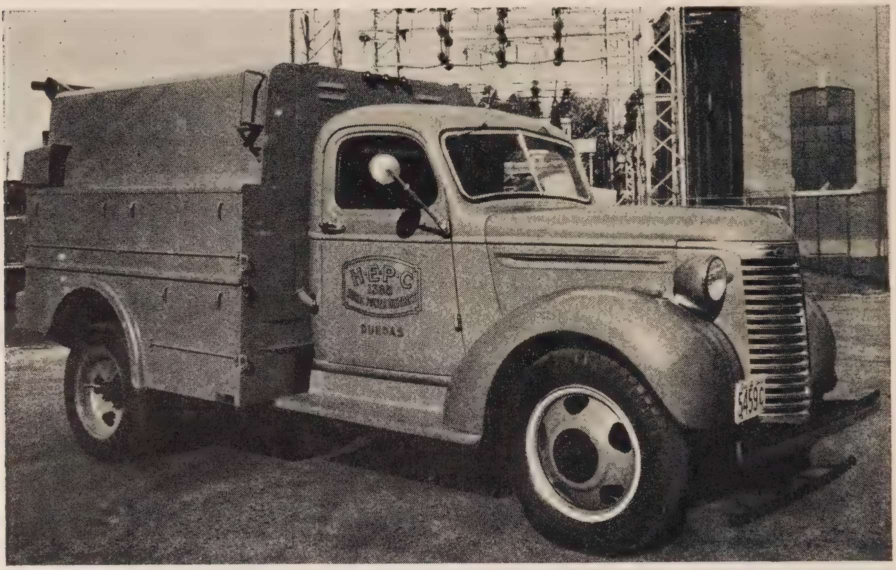
Fig. 2—A rear view of a 102 in. all-steel truck body for rural line construction work, showing telescoping pole derrick, winch equipment, etc. It is mounted on a 133 in. B.W. chassis having a gross allowable rating of 11,500 lb. Payload 4,800 lb.

is to say, if the general design, size and weight fitted the requirements. After approximately one year's study of these problems, the committee recommended the adoption of seven body designs which appeared most suitable, as also one light and one medium trailer, which are as follows:

1. Light service truck with special compartments, largely used for rural work.
2. Open express body truck with special compartments.
3. General utility truck with special compartments.
4. Station maintenance truck equipped as a travelling machine shop.
5. Forestry truck equipped with special seven-man cab.
6. General utility truck equipped with crow's nest ladder for maintenance of highway lighting.
7. General utility truck equipped with winch and derrick for pole raising.
8. One-ton utility trailer for handling three poles and one reel of cable.
9. Two-ton combination balanced-type trailer for handling nine poles or two reels of cable.

In designing these special bodies, the following points were given particular consideration:

1. Adequate arrangements to take care of the crew.



Illustrating the 102 in. all-steel truck body used for rural line construction. This unit is equipped with sliding roof, winch, derrick and subdivided compartment space for holding tools and equipment. It is mounted on a 133 in. W.B. chassis having a gross allowable rating of 11,500 lb. Payload—4,800 lb.

2. Sufficient boxes and compartments to handle the necessary equipment and materials required for the work to be undertaken.
3. Consistent with the strength required, the weight was to be held to a minimum.
4. Special equipment such as the winch and derrick, which would facilitate the work to be undertaken, would be furnished as part of the installation, and attempts were made to eliminate adding anything to the body once it was installed.

Heretofore, most of the body types supplied to the Commission were wood and metal construction. Through use over a number of years, these have been found not to have sufficient mechanical strength to resist the normal wear and tear, with the result that very high maintenance costs have been experienced. This resulted in studies being made concerning the use of all-steel construction, with a view to obtaining lighter weight, a more pleasing design and a lower cost of up-keep. Observations made during the past few years show that the wood-frame construction did not have sufficient rigidity and tended to weave considerably when rough roads were encountered, and in many instances resulted in considerable breakage of the metal covering and a loosening of the framing. In many instances the maintenance cost reached a figure approaching as much as 50 per cent of the ori-

The above shows an FWD truck with 12-ft. all-steel body designed to handle heavy line construction and maintenance for the Operating Department. This truck is equipped with a single drum winch and pole derrick equipment, besides associated utility equipment. It is designed with spacious compartments for tools and equipment.

Illustrating 138 in. all-steel station maintenance truck body. The seven-man crew accommodation has been accomplished by removing the rear of the standard three-man cab, and using a flexible connection joint, and installing a bulk head which increases the extra seating capacity as shown in Fig. 3. This body is designed with a sliding roof, zipper curtain in rear, sliding window, davit, and spacious compartments for tools and equipment. It is mounted on a 158 in. W.B. chassis having a gross allowable rating of 11,500 lb. Payload—5,000 lb.

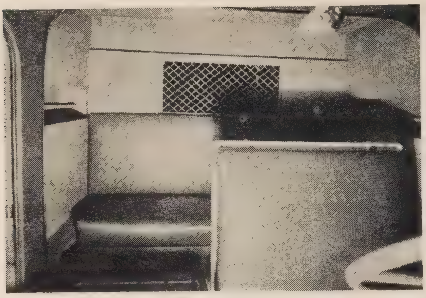


Fig. 3—An interior view of the seven-man cab for the all-steel station maintenance body.

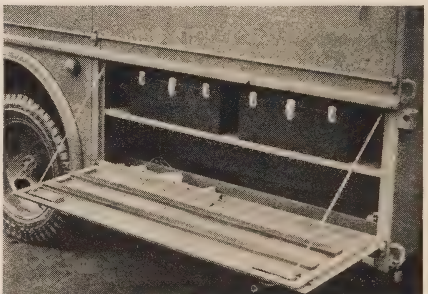
A side view of the all-steel station maintenance truck showing subdivision of compartment space and ladder rack, etc.

ginal cost of the body itself over a period of three or four years.

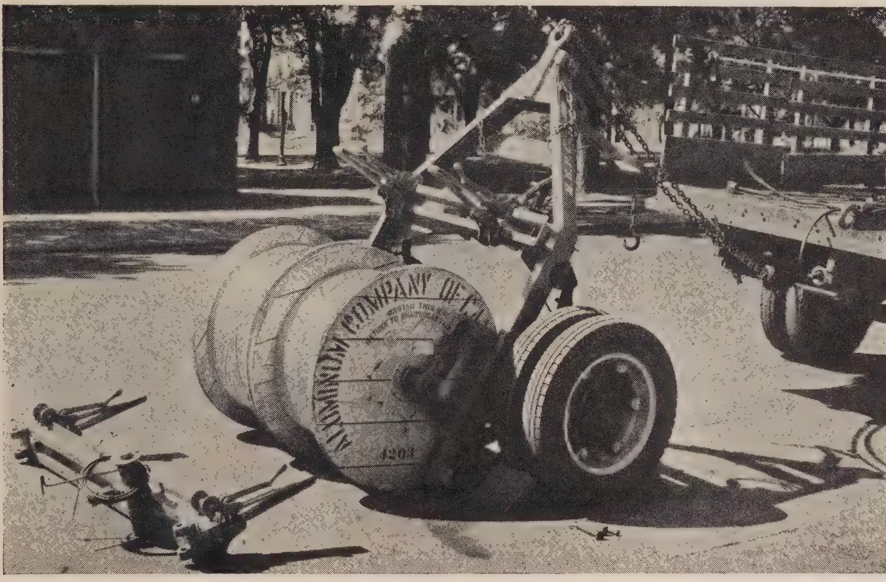
A recent survey of the various utility companies in the United States, together with observations here, would indicate that in selecting a body design, it must first be known in detail what is to be carried on the truck in the way of tools, equipment and men. Once these factors are known, a suitable body type can be selected without much difficulty, which will give service to a high degree and provide the convenience necessary for the employees using this equipment. Most of the utility companies in the United States specify in detail the tools, material and equipment to be carried, which as a matter of routine are inventoried once a month in order to prevent an accumulation of more tools, equipment and material than is necessary, a fact which if not observed, will result in the truck being finally overloaded, with a consequent shortening in life and increase in operating cost.

SERVICE TRUCK FOR RURAL WORK

A specially designed service truck has been standardized for rural work, consisting of a 90-inch, all-steel body mounted on a one-ton chassis. This truck is used principally for connecting or disconnecting services, meter reading, meter changing and light construction, and has been found to be a very efficient vehicle. The body has been designed with double steel doors on each side, which open to various compartments of different sizes, the partitions in the side boxes being removable. Fitting into one of the compartments

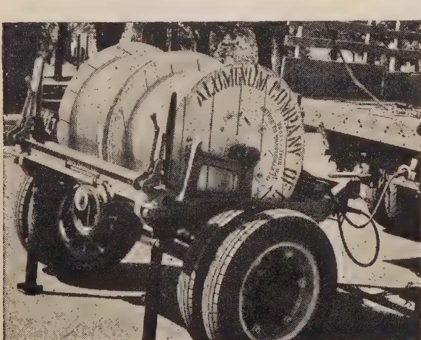


A side compartment opened, showing workman's tool boxes, etc. in an all-steel station maintenance truck. It also shows storage space provided below tool box shelf.

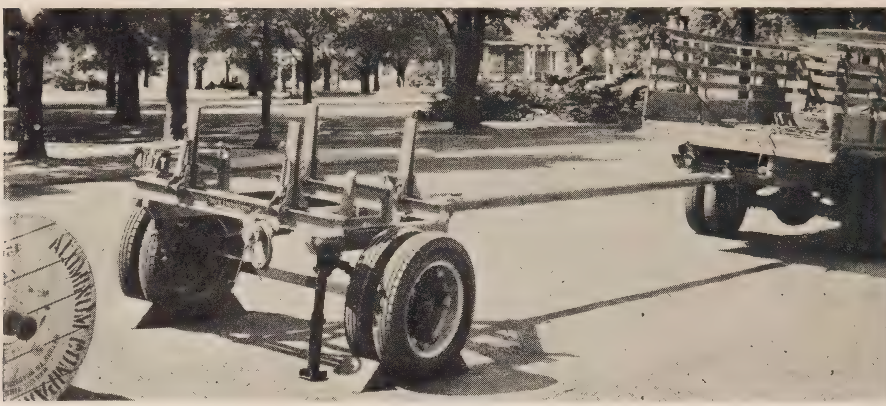


Combination Pole and Cable Trailer. This trailer is equipped with electric brakes and will handle two reels of cable 23 in. wide and 40 in. in diameter, or ten 50-foot poles. The above illustrates the method of picking up two reels of cable. Spindle is passed through centre holes of reels. Rear bunk of trailer is removed and trailer is tipped back into position shown with wheel chocks blocking wheels. Spindle is then located on lower end of trailer brackets. Note chain from tow hook to trailer eye.

are steel trays especially designed for holding sixteen meters, the meters being mounted on sponge rubber cushions to prevent injury while in transit. Hot line sticks are carried on the top shelf of one of the side boxes, and are removable through a small door at the rear of the truck. There is also an overhead ladder rack, together with a



Combination Pole and cable Trailer. View shows trailer after being pulled forward by the truck to horizontal position and coupled to truck. The reels have rolled down on the spindle on the trailer reel brackets to a position over the axle and spindle is locked in position with bolt. Rear bunk has been replaced, rigidly closing end of frame. Electric brake cable has been plugged into truck receptacle. When rear supports are retracted, unit is ready to haul to location.



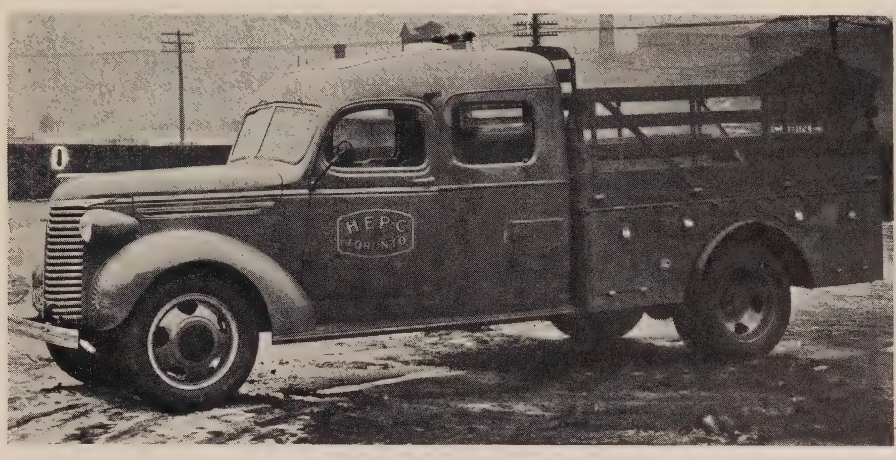
Above view shows the extension reach fitted to trailer and coupled to truck. Trailer is now ready for its load of ten poles, which are carried wholly on the trailer. Pole stanchions can be adjusted to desired position on bunks and locked with cam and lever device. Note that cable reel brackets remain in position and do not interfere with load of poles.

pay-out reel for handling weather-proof service wire. At the present time, the Commission has 49 of these trucks in the rural power districts, which are proving excellent vehicles for the particular needs.

Highway Lighting Maintenance Truck

During the past two years, the province has experienced the first installation of highway lighting on a large scale, this construction being on the Queen Elizabeth Way between Toronto and Niagara Falls. In order to construct and maintain this system, a crow's nest ladder has been installed on a 1.5-ton general utility truck, which has proven to be a very desirable vehicle, although it is believed ladders could be mounted on a one-ton chassis and be quite satisfactory. The ladders in question are adjustable to any desired inclination and to a point where men can work to the best advantage. They are designed to carry a 250-pound load, which for this type of work has proven to be quite sufficient. The ladders are demountable and the entire assembly may be freed from the truck by removing a single king bolt. It will be seen, therefore, that with the limited amount of highway lighting, it is not necessary to tie up a truck

One-Ton Utility Trailer. This Trailer is designed to handle three poles or one reel of cable.



Type D, forestry (seven-man cab) truck for transporting forestry squads and removing brush. Having facilities for carrying special tools and equipment.

with the aerial ladder when it might be used for other purposes.

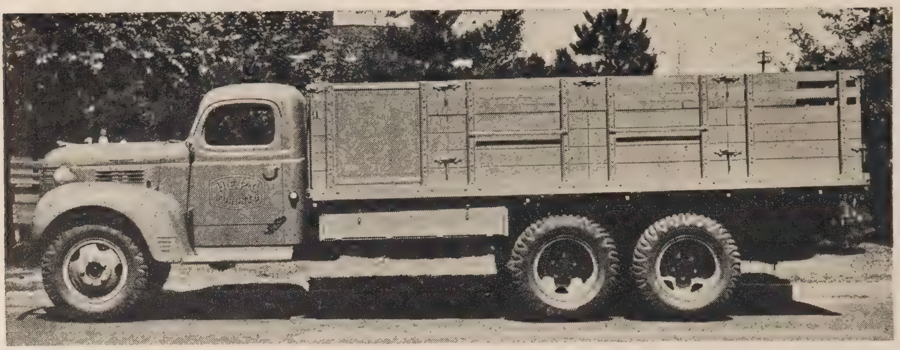
Derrick and Winch Equipment

Recently it has been found that derricks and winches mounted on 1.5-ton trucks are proving to be an efficient method of handling and replacing poles by both the Operating and Municipal Engineering departments. Several installations have been made on 1.5-ton trucks for handling poles up to 40 feet in length. The winch is operated by the truck engine and poles may be erected by this method, using a gang of three men in place of six or eight men as formerly. There are other uses to which the equipment may be put in the way of hoisting transformers, pulling out cable, etc. The winch is equipped with a jaw clutch control and drum brake. Hoisting and lowering is accomplished through the reverse power take-off controlled by a lever in the cab.

Heavy Construction Line Maintenance and Substation Maintenance Equipment

The Operating Department of the Commission requires, in the main, trucks of considerably heavier capacity than are used in rural work. Studies have been made of two different designs of bodies best suited for the work undertaken. In the case of substation maintenance, a body design was selected for mounting on a two-ton chassis, having all-steel construction, and designed in such

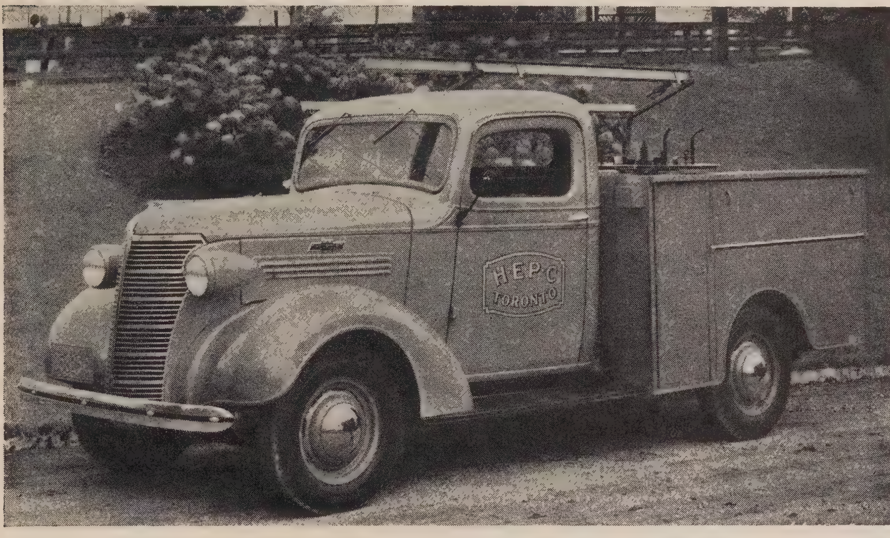
Interior of cab of Type D forestry (seven-man cab) truck.



Illustrating the conversion of a truck with a normal gross rating of 16,000 lb. to one having a gross rating of 30,000 lb. by reinforcing the chassis frame and using a tandem rear end with two dual purpose axles and dual wheels. It is used for heavy line construction work. Payload 18,000 lb.

a way as to accommodate all the tools and equipment required for substation maintenance purposes, together with provision for carrying men comfortably. This provision has been obtained in a very unique manner. The rear of a three-man standard truck cab has been cut away and let into the body by a flexible connection, the body itself having a bulk head installed approximately 2.5 feet to the rear of the forward end. By so doing, a provision is made to carry four additional men in the body of the truck, or a total of seven men in the crew. This design has some special features, permitting the bulk head to be moved forward and the space eliminated as far as man-carrying power is concerned, if so desired. The reason for incorporating this special feature, is to permit the same body design with some slight modification of tool arrangement, to be used advantageously as a heavy line construction truck, and, therefore, at any time a substation maintenance truck may be converted into a line construction truck with a minimum of expense. It is felt that with this body design, all the requirements of the Operating department may be taken care of with exception

Illustrating the usefulness of crow's nest ladders mounted on trucks. This type of equipment is used on the construction and maintenance of highway lighting and is very satisfactory.



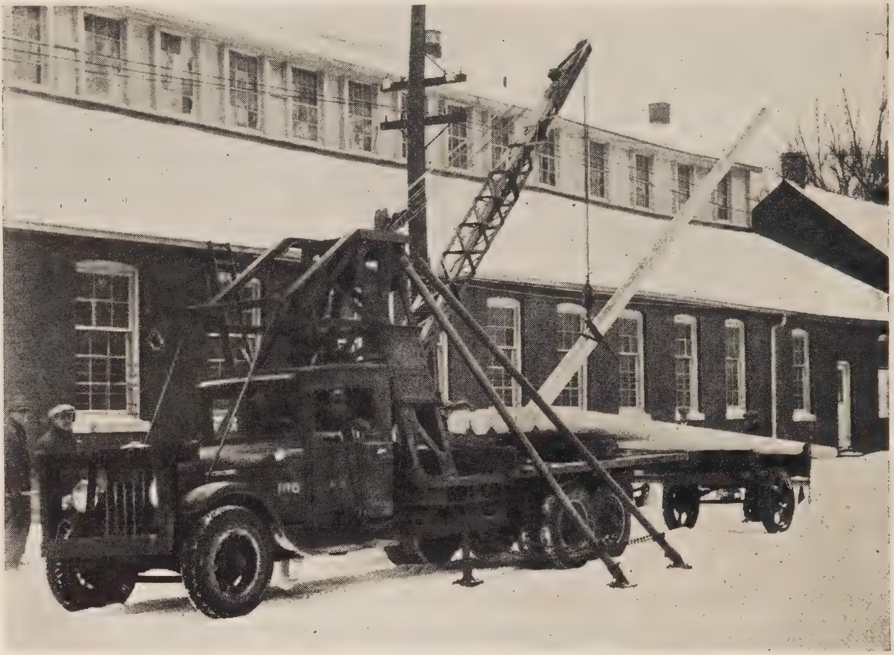
Type F, light rural service truck.

of one special design where a four-wheel drive is employed.

RURAL CONSTRUCTION

In the past, most rural construction has been taken care of by the type B truck, as illustrated in fig. 1. This design has a half-canopy with tool boxes on each side, the canopy being largely for the purpose of protecting men and tools from the weather. This design has not met with universal approval of the various rural superintendents throughout the province, and an attempt has been made to supersede it with an all-steel type, as illustrated in fig. 2. This latter type of design has a much larger body, a sliding roof, greater tool space, and is equipped with a zipper curtain at the rear to protect the men from cold weather in the winter and dust conditions in the summer. It is interesting to note that the design selected by the committee weighs approximately 1,000 pounds less than the type B, and this feature is considered to be very important due to the fact that the trucks are usually called upon to

Type F, light rural service truck. The above illustrates the special compartment spacing. Front compartments are equipped to carry 16 meters on trays. Long compartment fitted with shelves and adjustable partitions. This body is equipped with payout reel, hot stick compartment. Bodies available in 75 in. and 90 in. lengths



Heavy line construction truck used by Hamilton Hydro-Electric System.

carry a near maximum load at all times.

In general, it is felt that future body designs will be of all-steel construction, and while they may cost slightly more than the wood and steel construction, their life will undoubtedly be much longer; also the bodies may be transferred from one chassis to another when periodic turn-ins are made. By so doing, the final cost of supplying bodies for trucks will be very much less than under the present arrangement, especially when the lesser maintenance costs are taken into consideration.

Inspection System

The Production and Service department of the Commission, which is responsible for inspection and maintenance of the truck fleet, has a staff of inspectors who examine all trucks periodically. A careful study of this procedure has led to the conclusion that a systematic inspection has proven to be very beneficial. The work undertaken by the inspectors includes a general tune-up of the motor, removal of carbon, valve grinding, installation of rings where required, adjusting or relining brakes, installing king pins, bushings, and any items which require minor adjustment. The inspectors also recommend when trucks should be forwarded to the Production and Service department for a general overhaul or when replacement is needed. when a trucks needs a general overhaul, its history is reviewed by the truck committee, who makes the final decision as to whether it should

be turned in on new equipment or given an overhaul and operated for a further period.

Experience to the present would indicate that to obtain the most economical use of trucks, they should receive an overhaul at approximately 40,000 miles, and turned in for replacement at about 75,000 miles. A second overhaul has not proven to be economical as yet.

Oil Filters and Governors

Studies made concerning the use of oil filters have not yet been conclusive, but it has been determined that the cost of an oil filter may be saved in approximately one year's time through the lesser amount of oil required by the truck.

Governors are used on nearly all the Commission's trucks for the purpose of limiting the speed of the heavier vehicles to about 40 miles an hour and the lighter ones to around 45 miles on hour. The fundamental reason for their adoption was on account of a considerable number of engine bearing burn-outs, undoubtedly due to excessive speeds. It must be realized that the gear ratios in trucks are very different from those supplied in passenger cars, and speeds much above those permitted by the governor settings may give engine speeds comparable with passenger cars between 70 and 80 miles per hour. These speeds will produce high maintenance costs. Justification for the installation of governors on all trucks is found in the fact that there has only been one instance of burned-out engine bearings in a period of over two years.

Selection of Truck Chassis

Heretofore the usual method of denoting the carrying capacity of a truck chassis was in tons; that is to say, a truck may be of one, 1.5, two or three-ton capacity, which does not, as a rule, designate its true capacity, nor does it give an adequate means of determining a proper comparison between one manufacturer and another. In order that there may be no misunderstanding as to what is required when purchasing a truck chassis, the specifications for rating in gross carrying capacity are as follows:

	Type	Gross Allowable	Weight of Chassis, Body and Cab	Weight Pay Load
1-ton	"F"	6,000 lbs.	3,800 lbs.	2,200 lbs.
1.5-ton	"B"	11,500 "	6,000 "	5,500 " (Deduct 700 lbs. if winch and derick are used)
3-ton	Stake	14,000/16,000 lbs.	6,450 "	7,550 lbs.

It will be noted that the net weight available for carrying a pay load in a so-called 1.5-ton truck, is nearly double that given by the manufacturer. However, if gross allowable weights are not specified, it leaves room for the manufacturer in many instances to supply a substitute in the way of smaller tires or lighter springs, and sometimes to make omissions in some of the vital parts, resulting in a chassis much below

the standard required for the work to be performed.

Engine specifications are also important, and a review of this situation has shown that in a number of instances trucks have been purchased in which, undoubtedly owing to brisk competition, smaller engines have been substituted in order to meet a lower price level, with the result that when these trucks were placed in service, they were not able to perform the work in a satisfactory manner.

CONCLUSION

It would appear that in order to reduce the cost of utility transportation in Canada, some basis should be arrived at where all utilities, whether they be urban or the provincial system itself, should co-operate in some manner, particularly with the idea of establishing a limited number of standard designs in order that the various companies may be able to increase the volume of production, which should enable them to reduce the cost. The following are a few points which should receive serious consideration:

1. Reduction of the number of types to the smallest number possible.
2. Selection of types which will best suit the requirements.
3. Selection of a chassis which will not be overloaded.
4. A standard inventory of the material required to be carried, with a view to preventing overloading.
5. A continuous and adequate maintenance.

It is believed if these points are adhered to, especially with the use of all-steel construction, and equipping all trucks with oil filters and governors, that a marked decrease in th cost of utility transportation will result.

Appeal by O.H.E. Club Field Branch

The Field Branch of the Ontario Hydro-Electric Club has organized a committee for the purpose of conducting a campaign to collect funds to be contributed to the British War Victims' Relief through the Toronto Evening Telegram. The chairman of the committee is W. H. Mills of the Operating Department and the secretary, Miss A. W. Waring of the Line Maintenance staff, both stationed at Dundas.

The intent of this appeal is that the field employees of the Hydro-Electric Power Commission of Ontario unite to make a substantial donation to the British War Victims' Fund. As members of the Hydro family, they are asked to make this fund worthy of the people to whom it will go; to dig deep and show our people over there that we are proud of them.

Correction

In the February issue, page 44, the date of the death of Rev. F. C. Elliott should have been given as January 24th, 1941, and of Dr. T. F. Robertson, January 29th, 1941.

Accounting—Ancient and Modern

By R. Jarvie, Accountant, The Windsor Utilities Commission, Hydro Division, Windsor, Ont.

THE subject of Ancient and Modern Accounting covers a very large field and it would be quite an undertaking to try and do it justice at a meeting such as this where the time is limited. However we can look back as far as the records show and trace the outstanding facts in its progress. Its history is lost in obscurity, but researches show that methods of keeping accounts have existed from the remotest times. Records of a great banking house in Ancient Babylon have been found dating as far back as 2600 B.C., written on small slabs of clay and containing impressions from cylinder seals, and nail marks which were considered to be a man's natural seal. This incidentally might have been the forerunner of our finger printing system. Ancient Egyptian records were commonly written on papyrus, and contemporary pictures show a scribe keeping account of grain brought into, and removed from the Government Storehouse. So it is evident that some form of bookkeeping was in existence long before bound books were known. It is worthy of note that our modern system is leaning largely to the use of cards and loose leaf records so we cannot claim originality for something that had a similar existence thousands of years ago.

It is probable that at a very early period, so soon as trading transactions became too involved to be readily borne in mind, means would be found to keep some record of them. Thus we read in the Book of Ecclesiasticus "put all in writing that thou givest out or receivest in". From certain passages in Cicero and Pliny it seems evident that the Romans understood something of debit and credit so far at least, as to make entries falling under these terms upon opposite pages, though it is said they had a gentle way of repudiating the one and inflating the other, that would hardly be approved to-day. The earliest example of a bookkeeping record now in being, showing the date of transaction, its nature, and the money value, is probably a ledger in the National Library of Scotland, dated 1697. It is also interesting to note that this ledger was ruled by hand.

Previous to that, double entry bookkeeping had been in general use but when we come to look for anything definite regarding its date of introduction we find the records at variance. One reliable book of reference claims that it was *certainly not*, as

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Paper presented to the accounting session of the A.M.E.U. convention at Toronto on February 5th, 1941.

often stated, the invention of Lucas de Bergio in 1494. This, however, is the date of the first issue at Venice of a printed book entitled "Everything about Arithmetic, Geometry and Proportion" by a Franciscan monk, Luca Pacioli, which contains among other things an explanation of bookkeeping by double-entry as then understood. It is claimed that the system had been in use for about 200 years before that and it is recorded that it was used in Genoa in 1340. As an art, bookkeeping appears to have arisen in the great mercantile cities of Italy during the 15th Century and the principles of double entry (doppia scrittura) under the name of the Italian method gradually spread over Europe, many languages still retaining the original Italian names as technical terms. Perhaps Italy's early association with the subject influenced the legal requirements in that country that all transactions be journalized and so gave the name to what we now know as the Italian System of Bookkeeping.

Arthur S. Fitzgerald, Chartered Accountant of Windsor, in a recent article, quoted some rather interesting excerpts from a very old volume in the Edinburgh Accountants' Library which is unique in that it was written in verse. The introduction is as follows:—

In Sciences we're Nu'rous cases rise,
And ev'ry case a different rule applies,
The memory hardly can those rules rehearse
In prose, which it with ease can do in verse.

The author goes on to general rules for stating accounts,—

We debit that account which does Receive
And that which does deliver—Credit give
Moreover we're obliged in each transact
That science set forth clearly Right and Fact.

Something comes to, and nothing from us goes,
In such a case that something coming owes
Unto the account from whence that something came
Which likewise must have credit for the same.

When it comes to the ledger the author has this to say,—

Transactions herein divers courses take
Which we must note; and every turn they make
To note these justly, let this rule be read
Augmented's Debtor to Diminished.

Perhaps the author had violated his poetic license but it is recorded that he had fearlessly put into rhyme all manner of transactions dealing with bills and notes, exports and imports, exchanges, insurances, discounts, drawbacks and even of balancing for which he concludes as follows,—

Profit and Loss we next to Stock do bring
And stock into the Balance we do fling

If then the Balance, Equal-Poiz'd be
found
It proves our Postings Chequ'd and
method sound.

Several books on Bookkeeping appeared on the Continent and in 1543, Hugh Oldcastle, a teacher in London, introduced a treatise on Italian Bookkeeping. This system, with slight improvements from time to time, continued in use in Britain until the close of the eighteenth century when Edward Thomas Jones, an accountant in Bristol, published his "English System of Bookkeeping by Single or Double Entry." We are told that this work proved a complete failure, but it served a useful purpose in that it directed accountants' attention to the necessity of reconsidering the whole subject with the result that the system was evolved which was universally adopted and has been followed up to the present time. Here again we quote a different authority on this work of Edward Thomas Jones, where it is claimed that "Jones English System of Bookkeeping" as he called it was in reality a simplified and methodized form of the Italian double entry. At that time the opinion was expressed that this book was still regarded as the standard work on the subject and it was then in its twentieth edition.

Progress about the middle of the nineteenth century received impetus from the growth of limited liability companies and later from the Bankruptcy Act of 1869 which withdrew administration of insolvent estates from the hands of public officials. The advent of limited companies also led to business operations being undertaken on a large scale not previously thought of and we know how these have grown until the present time when companies have been merged into great corporations with connections and branches throughout the world. This expansion also necessitated the introduction of many special forms of accounts to take care of the changing conditions and they formed the foundation on which our present-day systems are built. The necessity of keeping proper books has been recognized by the legislature, and the Debtors Act (Scotland) 1880 contains provisions for the punishment of bankrupts who have failed to keep satisfactory books, while the English Bankruptcy Act of 1883 has a similar clause. A merchant's books frequently constitute important evidence in a court of law, and they should for this reason, if for no other, be kept as neatly and carefully as possible, for it is a common thought that bad bookkeeping is a cloak for illegal trading.

Bookkeeping is described as the art of recording commercial and financial transactions in a regular and systematic manner. Its object is to preserve a distinct and accurate record of such transactions and from a well kept set of books, a merchant should be able to ascertain at any time, the state of his account with any person with whom he has dealings, and the profits or losses from each venture or department of his business, his assets and liabilities and the exact state of his affairs. The stability of a business depends to a very large extent upon

the accuracy of the information thus conveyed, for without it, the trader, in ignorance, or with only a vague idea of his position often proceeds upon wholly erroneous and inflated ideas of his resources, and is only awakened to the real state of matters by the impossibility of meeting his liabilities when they fall due.

Many a bankruptcy may be traced directly to the errors and confusion arising from neglect or carelessness in this department. These considerations, however, are far from being universally realized and acted upon by business men. Among the class of small traders, especially, the time required for keeping books in proper order is grudged, as being unremunerative, and the work, if done at all, is performed in a careless and inefficient way, frequently with the disastrous results already referred to.

It may fairly be said that a just appreciation of the terms Debtor and Creditor affords a master key to the whole subject and blunders and confusion can easily arise from an attempt to follow slavishly definite rules without an intelligent knowledge of their meaning; for a comprehension of the general principles is much more important than a strict adherence to any particular style—however excellent. Mention is often made that we have two systems of bookkeeping—Single Entry and Double Entry, but many accountants say that is wrong. They claim that we may have *two kinds* of bookkeeping, but we have only *one system*—for they say that Single Entry is *not* a system at all. Many small traders still keep a record of their transactions in a rather slipshod way and the only books kept may be a cash book and a record of personal accounts. The Double Entry system which gives us two sides to every transaction is described as the true art of bookkeeping as it gives us clearly the requirements of clearness, completeness and accuracy. However complete and accurate it may be, it cannot make up for slovenliness or carelessness on the part of the bookkeeper and it cannot prevent many errors and acts of omission and commission.

We know that the subject is taught in many of our schools as a branch of commercial education but however far they may go in the teaching of its principles—the best school is still the School of Experience.

Owing to the advances made in its study and application, and due to the necessity of audits and the required higher standards of accounting knowledge, the professional accountant made his appearance. Possibly the earliest society of accountants, which was incorporated by Royal Charter, is the Chartered Institute—Edinburgh—in 1854, and since then many similar bodies have been created in all countries of the world. It might also be remarked in passing that the first professional accountant is claimed to be George Watson who was born in Edinburgh in 1645, and in addition to his accounting duties he had a large private banking business.

While the fundamental principles of bookkeeping are the same, the business requires that the books suit the undertaking, and we are all familiar with the general ledger and the books of original entry which

contain the details of all transactions. Beside the information required by the business itself, we find that legal enactments also, have had a great influence in the matter and the requirements of the Income Tax Authorities and the Government Statistical Departments, etc., have made necessary the need for a great deal of detail. Private and public liability companies, partnerships, etc., all have their special problems and the progress made was really consolidated in Britain by the Companies Act of 1908 and later by the Act of 1929. Special regulations have also been introduced covering bankruptcy, executor and trust accounts, insurance companies, finance companies, etc.

While this is of general interest we are primarily interested in those concerns which form a parallel with our own Hydro systems. In Britain, gas companies, railway companies, water companies, electric light companies and certain other companies of a public nature keep their accounts under what is known as the "Double Account System." Certain classes of these companies are required to adopt this system by the Acts of Parliament by which they are governed and they publish their balance sheet in two sections, one section known as the Capital Account shows on the left hand the capital expenditures on fixed assets, and on the right hand side the share and debenture capital. The second section, known as the General Balance Sheet, shows the floating assets and liabilities and also the balance of the Capital Account.

Another feature of this system is that all expenditure incurred in acquiring or constructing fixed assets is divided as between

(1) The cost of new and additional assets.

(2) The cost of assets intended to replace existing or formerly existing assets.

Expenditure of the first class is charged to Capital and when once so charged remains in Capital Account without any deduction for depreciation: Expenditure of the second class is charged to Revenue. The fixed assets, when once acquired are thus supposed to be permanently kept, out of Revenue, in an efficient condition.

It will be evident the expenditure on renewal of fixed assets will be comparatively light during the early years of an undertaking's existence, and will gradually increase as time goes on. It is therefore customary among companies which adopt the Double-Account System to charge to Revenue something in excess of the actual expenditure on renewals during these early years, and so build up a Renewal Fund to assist in meeting the heavier expenditure which will have to be incurred later; by this means the revenue charge for renewals is spread more evenly over the life of the assets.

It would seem possible under this system to build up very large reserves and it is well known that in the case of the British railways, over the long period of their existence, they show many sections of their permanent way at ridiculously low figures in comparison to their present day values, while in addition they have large Reserve Funds. This might seem like

an ultra conservative policy especially for a joint stock company but when they passed through the very hard times of some years ago it was the existence of these reserves which enabled them to survive. The policy of Reserve building seems to be rather common, and one of the most outstanding examples is the oft-quoted Bank of England Balance Sheet where the Bank buildings are shown at the nominal figure of £1 while the actual value can be anything in excess of one million pounds sterling. We know of course that life moves in cycles and, as of old, seven prosperous years can be followed by seven lean years so just how far we should go in providing for the future is still a moot point.

A brief reference might also be made to another publicly owned and operated organization which has attained very large and extensive proportions in Britain. This refers to the Co-operative movement. It embraces all forms of trading—manufacture, production and distribution—both wholesale and retail. Its mode of operation is somewhat different because in addition to the members holding shares in varying amounts they receive benefits also from a dividend on their purchases. The business of course does not take in the electrical field but it seems to cater for the public need in every other way, and we can leave its consideration to others as a subject of economics. Mention is made here merely to bring out the point that its growth was sufficient to warrant the issue of a sppecial text book on Co-operative Bookkeeping. It was produced in Manchester, England in 1904 and lays down established rules applicable to their particular requirements and methods of trading.

The uniform accounting for Municipal Electric Utilities which we use in our Hydro systems today is a revised edition and was compiled and issued by The Hydro-Electric Power Commission of Ontario in July 1915. We are informed that it was prepared to provide in full detail, the requirements of electric departments of municipalities operating under the Power Commission Act and subsequent amending Acts and Legislation. It clearly states that it differs from those in general use devised to control the accounting of private utilities under franchise, particularly in respect to the matters of Sinking Fund payments and reserves, Depreciation charges and reserves, Debentures Paid Account, and other features where the principles governing municipal operation differ from those applying to commercial operation by reason of annual debt reductions from revenue, which is at the same time charged to expense. This has long been a bone of contention with people both in and outside of our systems, but it would seem that, as previously quoted, controlled companies can establish themselves in an extra sound condition even if they show a considerable liability under their capital stock.

Reference might again be made to our present Hydro Accounting System for we find a similar set up was used in New York 30 years ago. It would seem they must have used the familiar American speed in its adop-

tion for it was not until 1896 that the first accounting body was recognized by the New York State. The early pattern may have been modified but it is still recognizable in a recent system introduced in the State of Wisconsin. This is prescribed and published by the Public Service Commission of Wisconsin as a "Uniform System of Accounts for Electric Utilities—Effective January 1st, 1938." It must be similar to others, if not all States, for it is described as being in substantial accord to that prescribed by the Federal Power Commission—Effective January 1st, 1937.

The requirements under the Commission are rather stringent and they cover all Public Utilities in the State. It is required that the accounts be kept in the manner specified and certain returns must be made as prescribed by the Statutes, under various penalties which can be imposed for failure or neglect to carry out the instructions. From various convention reports in the United States we find that this matter of Federal and State enactments in respect to statistical and accounting detail has got out of hand and complaints have been made repeatedly that the whole question has ceased to be a nuisance and has now become a worry. While we in Canada need not pass judgment in the case it would seem that we are certainly more fortunate by comparison.

To go into detail of the Wisconsin system would be too involved but consideration of a few of the items would no doubt be interesting. While we operate under three sections to suit varying sizes of our systems, they have only two classes—"A" and "B", and the particular class which applies is determined by the gross revenue and the original cost of the plant. They seem to have followed the recognized rule that it is better to have too many rather than too few accounts, and every conceivable transaction appears to be covered. Each account has a code number and *unlike* our Hydro accounts they have numbers for both Balance Sheet and Operating Accounts. Starting with number 100 which represents "Utility Plant in Service" they progress in blocks and thus we find No. 122 is for "Working Funds." No. 200 is Common Capital Stock, No. 250 reserve for Depreciation of Utility Plant. No. 600 starts the accounts necessary for recording the sales, and the operating expense accounts starts with No. 701. The accounts for the Assets and Liabilities are subdivided in various blocks to give the maximum of detail without making it necessary to analyze or break down a particular account and there does not appear to be any permission to group any of the items. Operating Revenue is covered by 16 separate accounts ranging from No. 600 for Residential Sales to No. 615 for Miscellaneous Revenues. In the operating Expense Accounts the numbers run from 701 to 809 and there is a separate account for each consecutive number without a break—in fact in quite a number of cases each number is subdivided—as for instance in the account for meter expense there is 762-1 "Removing and Resetting Meters," 762-2 "Testing Meters" and 762-3 "Miscellaneous Meter Expense." Altogether the Table of Contents consists of the following:

Abstracts from Wisconsin Statutes
Definitions
Instructions—General
Balance Sheet Accounts
Utility Plant Accounts
Earned Surplus Account
Income Accounts
Operating Revenue Accounts
Operating Expense Accounts
Clearing Accounts.

Under each class of accounts there are—Instructions, Schedule of Accounts and Text of Accounts, and altogether the whole text covers 174 pages.

When we consider the extent of these transactions we might take heart and realize that after all our Hydro Accounting Manual is not so formidable after all. Of course all the accounts are not used by every system in Wisconsin but they cannot adopt a free and easy method, for one of the abstracts from the Statutes says very distinctly "No Public Utility shall keep any other books, accounts, papers or records of the business transacted than those prescribed or approved by the Commission." While it is true that all transactions appear to be covered no doubt there will still be the same discrepancy when it comes to the question of interpretation of distribution and apportionment for, human nature being what it is, our personal interest influences our opinion, and we know how faulty appropriations can alter and distort the final picture of our operations.

In the United States there is a limit placed on the extent of the profit or at least on the dividend which can be declared and paid on the share capital. Consequently many of the utility companies expend large sums on the improvement of their plant and equipment and the standards of the personnel is kept high. In addition they have a great many services for their employees and all these outlays help to keep the profits within bounds. In Hydro we provide Power at Cost and our accounts are so arranged that the analysis can be determined for the different classes of our consumers. American utility companies of course do not operate on this basis, for they are not publicly owned, but if results show that an adjustment on rates is justified, then the consumers can make an appeal for such adjustment through the Commission which has the power to hear the case. Needless to say, probably appeals will only be made when some revision downward is desired, for the companies can be trusted to take any steps necessary when the existing rates are not sufficient for their operations. When the necessary investigations are made we see the advantage of uniform accounting, and comparisons can be made more readily. Possible differences can arise, for there are always circumstances which alter cases, and these can occur without any wilful desire to mislead. In our own Hydro life we know there are different problems which are peculiar to a particular town or system. There is no desire to break the rules but sometimes they have to be bent to meet the situation. Policies vary in different districts and they have their effect which are reflected in the yearly statement when we come to compare the details of the many reports.

The journey into the past may have

proved only of slight interest, but at least it has been a diversion from the usual procedure, and it serves to show that this particular field of endeavour in which we are interested certainly has a background. With regard to its present phase, it provides us with the opportunity to try and make our accounting system as perfect as possible, and being a publicly owned and operated organization, we know we have every facility to supply the example of a perfect model in our books of account.

A.M.E.U. Committee Report

Report of Rates Committee

The A.M.E.U. Rates Committee held one meeting during the year, viz., in Toronto in December. At this meeting the committee reconsidered its report for 1939 which was presented at the Winter Convention at Toronto on Tuesday, February 5th, 1940, and which was referred back to it. The revised report is given as follows, with references to other matters taken up.

Flat Rate Water Heaters

Suggestions had been received of giving an extra discount when flat rate water heaters are controlled. By controlling this load power would be made available for other purposes, as also distribution system and line transformers. Against such saving there is the expense of installing the control system. The committee made the following suggestion:

When the flat rate water heater load in a municipality is controlled, that the rates to all flat rate water heaters in the municipality be made uniform, i.e., there will be no distinction as far as rates are concerned, whether the heaters are controlled or not. The suggestion of using extra discounts in such municipalities is not considered desirable. Where the tank is installed the rental for the tank should be added to and included in the rate.

In municipalities where there is no general system of control of the flat rate water heater load but where some method is adopted of controlling certain individual heaters, application may be made to The Hydro-Electric Power Commission of Ontario for a special discount to be used in the billing of such controlled heaters based on conditions existing in the municipality.

In municipalities where the flat rate water heater load is controlled, 25 per cent should be deducted from the kilowatt-hours used for the purpose of splitting costs for system analysis.

For the purpose of system analysis, the cost of installing flat rate water control should be charged to the whole system and split on demand.

Re 75 Per Cent of Demand Rule

The suggestion was made at the 1939 Summer Convention, that the present ruling for decreased load, of billing on the basis of not lower than 75 per cent of the previously estab-

lished maximum demand be considered to ascertain if this limit could be lowered. This was referred to The Hydro-Electric Power Commission of Ontario, whose Rates Committee advised that, since with the present 75 per cent limit, the net revenue from service charge without considering class or local discounts became 67.5 cents per horsepower per month of the previously established maximum demand, it did not consider a reduction of the present limits desirable, when compared with the cost of the service. A concession might be made when requested, however, that while retaining the present limit of 75 per cent applying to the service charge, by dividing the kilowatt-hours on the basis of actual demand. This committee accepted the Commission's suggestion, this change to apply to power users only, commercial lighting service to remain unchanged.

Neon Signs

Attention was directed towards the lack of uniformity in marking Neon signs to show their rating, and also to the present rulings governing billing for them. The Hydro-Electric Power Commission was asked to take steps toward having a uniform method of labelling the signs in an accessible location, and also to consider rewriting the rules for billing these signs, taking in fluorescent lighting. The Commission's Rates Committee advised that the matter of labelling Neon signs had been discussed with the Electrical Inspection Department, and instructions had been given to that department to establish a uniform method of labelling them, giving the rating in amperes and volts, the label to be placed in an accessible location. The Commission's committee recommended that no change be made in the wording of the present rules for billing. This report was accepted by this committee.

The committee has asked The Hydro-Electric Power Commission of Ontario to make a study of fluorescent lighting, particularly where no power-factor correction equipment is installed.

Small Loads, Intermittent Loads and Elevator Motors

The question was brought up as to the intent of the rules for billing for small loads and for intermittent loads, referring to Clauses 45, 46 and 47 of the Standard Interpretations of Rates. The Hydro-Electric Power Commission of Ontario was asked to reword these clauses so as to clarify the intended meaning. The Commission's Rates Committee submitted a suggested revision for Clause 45, "Service to Small Loads" which was amended slightly and accepted. The proposed new Clause 45 is:

"Unless a polyphase street main at motor voltage passes the consumer's premises, installations of less than 5 horsepower will be given single-phase service. If polyphase service is required by the consumer for less than 5 horsepower, and it is not already available from existing polyphase street mains, such load may be billed on a minimum of 5 horsepower."

The Commission's Rates Committee submitted a suggested rewording of Clauses 46 and 47, "Intermittent

Rated Equipment" and "Elevator Motors" which endeavoured to clarify the intention of these two clauses. The suggestion was accepted for application except in municipalities where there are special conditions, and the Commission was asked to write the clauses in their final form.

In order that there will be no misunderstanding as to the capacity of intermittent rated equipment, The Hydro-Electric Power Commission was asked to take steps to have all such equipment supplied with nameplates, put on by the manufacturers, showing the rating as "intermittent".

Service to welders was introduced, but discussion of this subject was left over for a future meeting.

Short Term Power

The Committee was asked as to its understanding of a sentence in the clause in the Standard Interpretations of rates regarding short-term power "The consumer shall pay the cost of providing or removing the additional equipment required for this service", whether the intention was that the consumer should pay for one or both items of "providing" and "removing". The committee ruled that the intention was that the consumer pays the cost of both of these items.

Also an explanation was asked of the last sentence of the same clause "Short Term power contracts may be permitted for restricted power during the winter months, namely, from November 1st to the last day of February". It was ruled that if restricted power is available it could be sold under short term contracts, subject to the extra discount for restricted service. Otherwise it would be sold only on the unrestricted basis.

Month and Calendar Month

The Hydro-Electric Power Commission of Ontario was asked to prepare a clause for insertion in The Standard Interpretations of Rates defining the words "month" and "calendar month" as used in them. This was deemed necessary since a legal decision has been handed down based on the interpretation of these words.

Signed on behalf of the Committee,

W. R. CATTON,

Chairman.

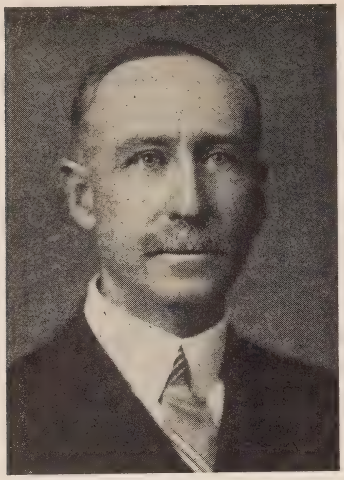
J. G. Archibald, Woodstock, Retires

After forty years of service to the city, J. G. Archibald resigned from the position of manager of the Woodstock Public Utilities Commission on March 1st, 1941. He will continue to make his home in Woodstock, and has been retained as a consultant to the Commission.

Mr. Archibald is a native of Nova Scotia, and received his first electrical training with the Halifax Electric Light Company. From there he went to an electrical construction company which carried on work in different parts of New York state.

In 1891 he came to Woodstock to take charge of the electrical plant of Patrick and Powell who were supplying electricity and also gas in Woodstock at that time. Shortly after, however, he left to accept a position in British Columbia.

On March 1st, 1901, the city purchased the electric plant from Patrick



J. G. Archibald

and Powell, and Mr. Archibald returned from British Columbia to become manager of the plant, which was moved into a new part of the waterworks building. Later with the formation of the Public Utilities Commission, electricity and water both came under his management. When he first took over the management for the city, the staff consisted of himself, one lineman and one fireman. The plant served 60 arc lamps on the streets, two homes and a few store windows. Woodstock joined the Hydro movement in 1905, and was one of the first to take power from The Hydro-Electric Power Commission in 1910. The contract was for 1,200 horsepower, and the load taken during the first month of operation, December, 1910, was 450 horsepower. Since that time the Woodstock load has grown to an average load during 1940 of nearly 7,000 horsepower, and the system has required the addition of three substations. The present office building was bought and remodelled in 1919.

Prior to Hydro the rates for lighting service were 8 cents per kilowatt-hour, plus 20 cents per month for meter rental. In 1939 the net cost per kilowatt-hour to consumers for domestic service was 1.1 cents and for commercial lighting service 1.3 cents.

Mr. Archibald has many local interests in Woodstock in which he is an active worker, and it is our wish that he may be long spared to enjoy his well-earned leisure.

Woodstock's New Manager

On the retirement of J. G. Archibald from the office of manager of the Woodstock Public Utilities Commission, J. Russell Sullivan, assistant manager, was appointed manager. Mr Sullivan is a Woodstock boy, having been born and educated there. He spent some time at the Canadian Westinghouse plant at Hamilton, and the Chevrolet Motor Car Company at Flint, Michigan. He also spent several years with the International Nickel Company at Copper Cliff at Creighton Mines and at High Falls.

In 1920 he joined the staff of the Woodstock Public Utilities Commission, and has since served there continuously as assistant, in charge of the electrical and water departments.

The Bulletin joins with his many friends in congratulating him on his appointment, with the hope that as time goes on he will make a record similar to that of his predecessor.

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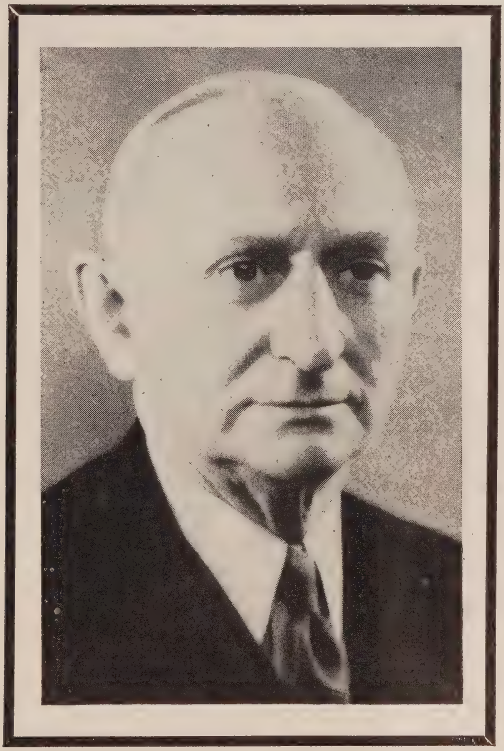

H. C. Don Carlos

HENRY CARTER DON CARLOS, chief operating engineer of The Hydro-Electric Power Commission of Ontario, passed away at the Private Patients Pavilion, Toronto General Hospital, on Saturday, March 29, 1941. On Monday, March 24th, he attended his duties at the office as usual, but on the following Wednes-

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Vol. XXVIII No. 4

APRIL, 1941

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

day was admitted to the hospital suffering from pneumonia.

"Don" was born in Cooper County, Missouri, in 1875. Upon graduation in Electrical Engineering from Missouri State University in 1902, he joined the Colorado Fuel and Iron Company at Pueblo, Colorado, but a short time later went to the Telluride Power Company at Telluride, Colorado, being engaged in power house operation and maintenance. In 1904 he was made engineer in charge of electrical, mechanical and hydraulic engineering of the Colorado Division of the Telluride Power Company. In 1906 he was transferred to the position of superintendent of a subsidiary company, the Eureka Electric Company, Eureka, Utah, where he had charge of local distribution work, reconstruction, transmission line construction, substation design and construction, and also of electrical installations for mine hoists and pumps. He left the Telluride Power Company in February, 1912, to become operating superintendent of The Hydro-Electric Power Commission of Ontario. Shortly after this he was appointed operating engineer and placed in charge of the operation and maintenance of all of the Commission's transformer stations, transmission and distribution lines; as the Commission expanded and generating stations were acquired or built, the operation and maintenance of these plants was also placed under his supervision.

In professional circles he was a fellow of the American Institute of Electrical Engineers, serving as Chairman of the Toronto Section in 1924 and 1925, and as a director of the Institute from 1926 to 1930. He was a member of the Association of Professional Engineers of the Province of Ontario, being registered in the Electrical, Civil and Mechanical Branches. As a member of the Engineers Club of Toronto, he served for a time on the Board of Directors and in 1939 was president of the club.

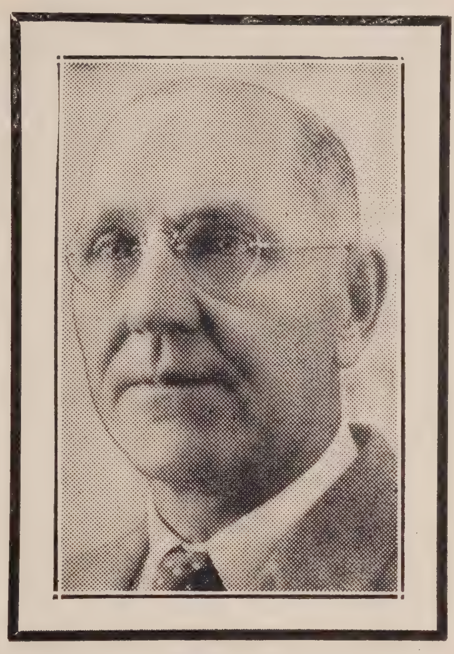
Prominent in engineering circles during the whole of his career, being

widely known both in Canada and the United States, particularly among electrical engineers, the honours accorded him indicate the universal esteem in which he was held and bear witness to his abilities, which he freely offered in the service of the engineering profession and of the community at large. His interests extended beyond technical matters; he was an excellent golfer, an ardent hunter and fisherman.

He possessed the happy faculty of making friends readily, and numbered them in many walks of life. In all departments of the Hydro, both in the Head Office and in the field, his loss as a leader and a fellow worker, but above all as a friend, will be most keenly felt.

Mr. Don Carlos is survived by his widow, one son, Allan, who is on the Commission's staff and three daughters, to all of whom we extend sincerest sympathy.

J. E. B. Phelps, Sarnia



James Edward Blake Phelps, Manager of the Sarnia Hydro-Electric Commission, died in the Sarnia General Hospital on Thursday, April 24th, 1941, after a short illness. Had he lived until June he would have completed a quarter of a century as manager of the Sarnia system.

Jim was born in 1873 at Springford, Oxford County, but at the age of eleven years went to Point Edward to work in a grocery store operated by his uncle. Subsequently he went railroading and worked a short time as fireman on the Grand Trunk Railway. In 1900 he entered the employ of the Sarnia Gas and Electric Light Company as fireman. Realizing the disadvantage he was placed in the engineering field by not having obtained an engineering education, he at once enrolled for a course with the I.S.C. and although working on a daily shift of twelve hours, seven days per week, he found time to pursue his studies and obtain his diploma. In three years time he was chief engineer and electrician of the company. In June, 1916, the plant and distribution system were taken over by the city and he was appointed manager.

When he started with the company the plant contained one 500 light a.c. generator and a 50 light arc machine. The load taken by the Sarnia system during November, 1916, the first month of Hydro operation, was 268 horsepower. The average load taken

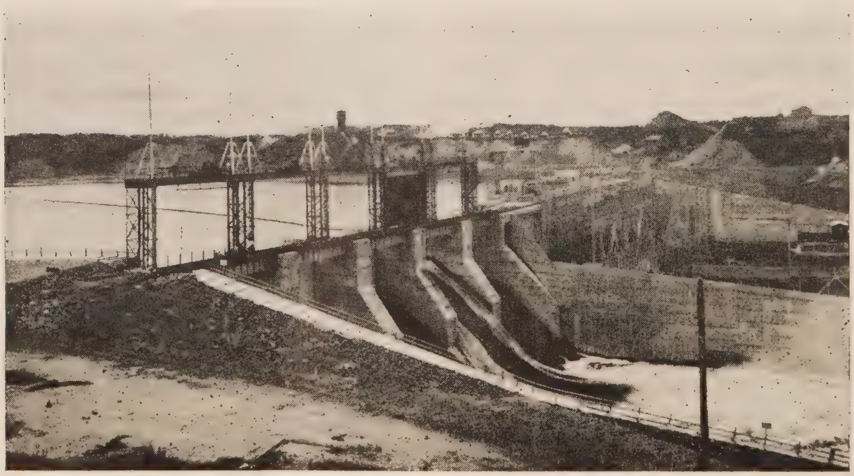
during 1940 was 8,806 horsepower. Prior to Hydro, lighting service was supplied at the rate of 6 cents per kilowatt-hour. During the year 1939 the average cost to consumers for domestic service was 1.5 cents per kilowatt-hour, and for commercial lighting service 1.4 cents.

Mr. Phelps was a member of the American Institute of Electrical Engineers and of the Association of Professional Engineers of the Province of Ontario. He was president of the Association of Municipal Electrical Utilities in 1924.

Affectionately known as the Father of Hydro in Sarnia, he took an active part in supporting the move to have Hydro brought to Sarnia. Since then his popularity in Hydro circles has extended all over the province and his ready assistance in discussions of problems arising out of the operation of the utilities will be missed greatly.

Canadian Minister to U.S. Former Hydro Employee

Loring Christie, Canadian Minister to the United States, who died on April 8th, 1941, served for two years on the staff of The Hydro-Electric Power Commission of Ontario. In 1927 he came to the Commission as special advisor to the chairman, C. A. Magrath. In this capacity he assisted Mr. Magrath in negotiating with the Gatineau Power Company for power from Quebec and in the preparation of agreements covering its delivery. He also took a part in the discussion of international and interprovincial water rights in regard to their bearing on Hydro.



Main dam, from sluiceway end, Abitibi Canyon development.

Planned Wiring for Planned Lighting

By E. W. Moodie, Illuminating Engineer, H.E.P.C. of Ont.

ELECTRIC lighting is inseparably linked to electric wiring. Wiring can exist alone, but lighting cannot. Copper wires are the essential link between generation and utilization, and all our lighting progress has marched down these metal highways. We have developed a "Science of Seeing", but do not let us forget that at the same time and with equal rapidity, there has grown up the "Art of Electric Wiring". Recognition of the new art, and application of its techniques, will provide the only sure road down which our lighting programs can succeed.

Lighting men dislike wiring. To them it is uninteresting and confusing. They do not understand it, and so avoid coming to grips with it. And although a lighting plan without wiring is only half a plan and impossible of realization, we go blithely on our way marking outlets and wattages, specifying fixture types and hoping fervently that nobody will ask embarrassing questions about the wiring. We know the customer cannot himself meet the need for an intelligent wiring plan, but we nourish a secret hope that some "progressive wireman" will be called in to take up the sales story where we have left off, sell the really hard part of the job, and then engineer and install a wiring system that will fulfil the many requirements of modern usage. And by virtue of these happy circumstances our customer can then proceed to make the lighting installation so carefully planned by us, with a good assurance that it will function successfully.

And bitter experience notwithstanding, we press ever on developing better illuminants, better techniques and better sales stories but avoiding always the troublesome wiring problem. Our most carefully engineered plans get strangled in tight wires, and lost in a confused maze of conduits, panels, feeders and wiring appurtenances.

Surely there is need for collaboration between interests so interdependent as those of wiring and lighting, and it seems to me that a challenge is presented here for more interchange and co-operation. We lighting men have much to learn and we have something to impart. A Science to give and an Art to acquire.

It is encouraging to note therefore that our Society has recognized the need to the extent of collaboration on a Handbook of Interior Wiring Design. If you are not familiar with this book, I recommend it to your careful study. And although I do not recall any papers on the subject of wiring in our Toronto Chapter, some

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A paper presented in part before the first Canadian Regional Conference of the Illuminating Engineering Society at Toronto, March 19, 1941.

very fine ones have been presented at the Annual Convention, as you probably know. We are slowly but surely awakening to the need.

Wiring has unfortunately lost caste throughout the years because of the old time carpet-bagger wireman. This man may have been a good enough mechanic, but as soon as he was faced with Ohm's law he retired in a panic. His concept of planned wiring was to cajole the electrical inspector into special rulings for a minimum job, and to satisfy code requirements only after issuance of several defect notices by the Inspection Department. He was usually in business for himself, which meant that he was in debt to every wholesaler in town and was at best unable to do more than get paid for his labour, and rather poorly at that. I heard of a case where one of these men was at last able to retire on $100,000 and go to Florida to enjoy the rest of his years. It turned out that an uncle had died and left him $99,900. Representing the wiring industry as these men were, meant no good for the industry.

On another hand, wiring has lost prestige because of a too common type of fixture salesman whose only concern was to sell fixtures and lamps, and who thought any two wires showing through the ceiling offered legitimate excuse to make a sale. Any need of re-wiring was minimized for fear of losing a sale, and electricians and inspectors alike were persuaded to the limit so as to keep the wiring expense to the irreducible minimum. Every wiring job was given for quotation to many contractors on the assumption that at least one would make a mistake and the job would profit at his expense. But while the contractor lost, the job lost more, and the level of the entire industry slipped just a little.

To-day fortunately, these well known types are passing. Every large contractor has one or more engineers on his staff, and the influence of such fine associations as the National Electrical Contractors and the Service Leagues, are spreading wider and going deeper. The fixture salesman has become a lighting engineer, and begins to realize that a lighting job must be sold complete, and that the rewiring will cost several times as much as the re-fixturing.

But we are not out of the dark woods yet, and before we see the clear, there are many trees to be felled. With unity of purpose and ordinary good sense we can work out, among us all, the many problems in our path.

May I mention the place of the Consulting Engineer in this picture. If all jobs were engineered by these men our troubles would be largely over. But unfortunately they are not, because the bulk of all projects are not of sufficient individual value to justify in the public mind engagement of such specialized counsel. The Consultant is not therefore a universal electrical advisor to the building industry, but is engaged almost exclusively upon large projects which in bulk constitute only a small part of the whole. We cannot, under present circumstances, depend upon his excellent work to save us from our major difficulty.

Planned lighting is a vast subject which you will readily admit, and we

spend long hours of study and discussion upon its many complexities. Planned wiring is probably as large a subject, certainly far too large for any adequate description in the time at our disposal to-day. There is time to mention only a few high spots as we review some essential factors governing its design and use.

1. It must provide Distribution.
   Distribution requires:
   —conductors
   —conductor raceways
   —load centres, panels, bus bars, transformers
   —feeders, sub-feeders, branch circuits
   —outlets.

2. It must be Safe: (a) to human life; (b) against fire.
   Safety requires:
   —insulation
   —identification of conductors
   —grounding
   —protection of live parts
   —mechanical protection
   —overload and short circuit protection
   —protection against dampness, explosive mixtures and other special conditions.

3. It must be Efficient.
   Efficiency requires study of:
   —adequacy of conductors (wire size, distance, line reactance and power factor)
   —regulation (voltage factor)
   —wiring system employed (voltages and phases)
   —wiring method used
   —type of equipment.

4. It must be Reliable.
   Factors affecting reliability are:
   —mechanical strength and positive electrical contacts
   —low rise in conductor temperature
   —design for maximum demand.
   —transfer switching and dual feeders
   —circuit breakers and fuses of proper characteristics.

5. It must be Flexible and allow for Growth:
   These require consideration of:
   —switching and control
   —adequate raceways (square duct, bus duct, floor duct, cellular metal floor raceways, hollow base boards, trolley duct)
   —adequate circuits
   —unit switchgear
   —liberal use of imagination, experience and intelligence.

6. Economical Installation.
   This requires a complete knowledge of equipment and wiring systems as well as modern installation methods. Basic units of cost per ampere foot of conductor, and cost per installed kv-a. should be worked out for various systems in the case of each job before economic selection can be made.

It becomes apparent from this very sketchy outline that planned interior wiring for all its simplicity of purpose, becomes a very complex and interesting study, and is capable of an almost infinite variety of arrangement.

There are those who think that, given a plan with outlets properly located, there is nothing more to wiring design than to join the outlets all together like a bunch of grapes, specify

two per cent maximum volt drop, and depend on the electrical inspector for the rest. The electrical inspector performs an essential and important service, but he cannot insist on more than minimum safe requirements for life and fire hazards. Vague requirements such as two per cent maximum volt drop are usually meaningless, unenforceable, and an indication of our own lack of knowledge. We are passing the onus of design to the many contractors who are bidding against each other, and who know that the design which will cover up the maximum skimp will get them the job.

The first step in planning wiring is to size up the building itself: what materials it is made of; the structural design; what use it will be put to; what special conditions there will be; what future uses and demands it may be subject to, and many similar observations.

If it is an existing structure it will be necessary now to survey the present wiring system, decide what use if any can be made of present circuits, raceways, etc., and note on the plan possible panel locations, pipe shafts, closets and the like for concealment of risers and equipment, and then relate the information to the proposed new lighting layout.

For use in our own service work we have developed a wiring survey form for handy check by the field man of many of these points. It is not perfect, nor even complete, being a first attempt, but it indicates the importance we attach to this kind of information. The data we get in this way permit us to give the customer some genuinely useful advice which he can then pass on to his electrician to the benefit of all concerned. The forms are good for small and moderate jobs where there is no complexity of equipment.

Let us consider briefly the problems involved in modernizing an existing structure. There are 7 functional divisions to study in an old building where re-wiring is to be done, and any one or all of these may prove bottlenecks to the re-lighting program:

1. Service entrance.
2. Main switch or breaker.
3. Switchboard or distribution panel.
4. Feeders.
5. Panels.
6. Home runs.
7. Branch circuits.

Service Entrance

The service entrance can often be re-located to great advantage and an "electrical room" provided to house the equipment. Study of power rates may suggest purchase of primary power with provision by owner for necessary transformations. Original lines are seldom adequate and installation of new ones allows operation of old equipment while job is being done.

Main Switch or Breaker

Replacement is almost certain. Air circuit breakers offer many advantages for main protection on heavy low voltage lines. Where banked service switches are used for distribution feeder protection, the existing main service switch can often be re-used for this purpose.

Main Switchboard

It seldom pays, nor is it practical, to rebuild old equipment. Factory as-

sembled unit switchboards are neat, safe, easily installed, and flexible in application. In smaller jobs choice must be made between panels and gutter box assemblies, and if space is limited the panel may be essential. Neatness and ease of installation are characteristic of the panel, while cheapness and flexibility mark the gutter box load centre. Where use is made of old cutouts, it is a good idea to use fuse clip clamps.

Feeders

Increasing feeder capacity is an individual problem for every job. Existing risers can often be used to feed one panel of a run of 2 or 3 above each other, new feeders being carried to the upper ones. An old feeder may be paralleled by a reinforcing feeder of equal size and length if the cables of like polarity are sweated into the same lugs. Increased voltages are sometimes used in large projects to obtain the necessary increase in load capacity in existing feeders.

Panels

Because of the more compact design of modern panels, new interiors can often be installed to advantage in the existing cabinets or tubs which will afford ample room for the increased circuits, and into which existing conduit runs are terminated. New trim will be necessary to fit the new interior and old cabinets.

Home Runs

If existing home run conduits are inadequate, surface raceways in the corner of corridor ceilings are often a very good means of solution.

Branch Circuits

These usually constitute the largest job in the changeover, and the most troublesome. New insulations of 2/64 in. thickness instead of 3/64 in. as at present specified, allow the current carrying capacity of present raceways to be increased as much as 3 times. These "thinwall" wires as they are called, have been approved by the National Board of Fire Underwriters for use in existing structures, and have already been extensively used with great success in the United States. They usually make the modernization plan possible without installation of new conduits, reducing the cost thereby and avoiding cutting and otherwise marring of the building. They are not approved as yet by our own Canadian Electrical Standards Association which are investigating their possibilities. There are certain considerations in respect to low temperatures, mechanical strength, braid and use for new construction that have to be taken into account.

Few people realize that inside buildings we have, in the aggregate, the largest distribution system in the world, with the most miles of wire, the largest dollar investment. If we are to be worthy guardians of the lighting industry we must be prepared to tell the public the whole truth in respect to a more abundant use of artificial light, and be better prepared our own selves to render this needful service.

H.E.P.C. Laboratory Industrial X-Ray Unit

By D. G. Watt, Assistant Testing Engineer, H.E.P.C. of Ontario

DURING the last fifteen years engineers have shown an increasing interest in utilizing X-rays for determining the soundness and freedom from defects in structural materials. Just as human bones and organs may be viewed on the fluorescent screen or recorded on photographic film by means of X-rays, so may any structural or machine part, whether it be made from metal, masonry, wood, rubber, plastic or ceramic materials, or assemblies of these, be radiographed without damage to reveal the presence of hidden faults or careless workmanship. X-rays thus furnish the engineer with a non-destructive inspection tool which is applicable to practically all materials.

As such it has many uses. Among these may be mentioned the promotion of safety by proving the soundness of fittings or devices on the strength of which human life depends; the prediction of satisfactory operating performance of castings, welds or other parts used in engineering structures or machines; the improvement of foundry technique by X-ray study of pilot castings and the elimination of expensive machining operations on defective castings.

So useful and varied have become the applications of X-rays in industry that it was decided to install in the Laboratories facilities for conducting this class of work. It was thought that X-ray equipment would prove particularly useful in examining linemen's spurs and other safety devices, important aluminum, copper and steel castings, conductor joints, insulators and the like.

After a preliminary study of the available equipment and the Commission's present requirements, an X-ray unit was purchased, installed and placed in operation in December of last year. It consists, essentially, of a 150 kvp., 1.5 millimeter line-focus, shock-proof, ray-proof, water-cooled X-ray tube excited by a high potential transformer through a full-wave synchronous mechanical rectifier. The arrangement of the apparatus is such that it may be used conveniently for either fluoroscopy or radiography.

In Fig. 1 the unit is shown arranged for taking a radiograph or X-ray picture of a number of cast aluminum conductor joints. These are placed under the tube on top of an X-ray film, enclosed in a light-proof holder, supported on a lead-topped adjustable table. After the proper exposure, the film is removed from the holder in a dark room and developed by practically the same method as photographic film. Where several exposures are required, a lead sheet housing completely surrounding the tube, subject and film, may be secured to the table to protect the operator from the injurious effects of scattered radiation.

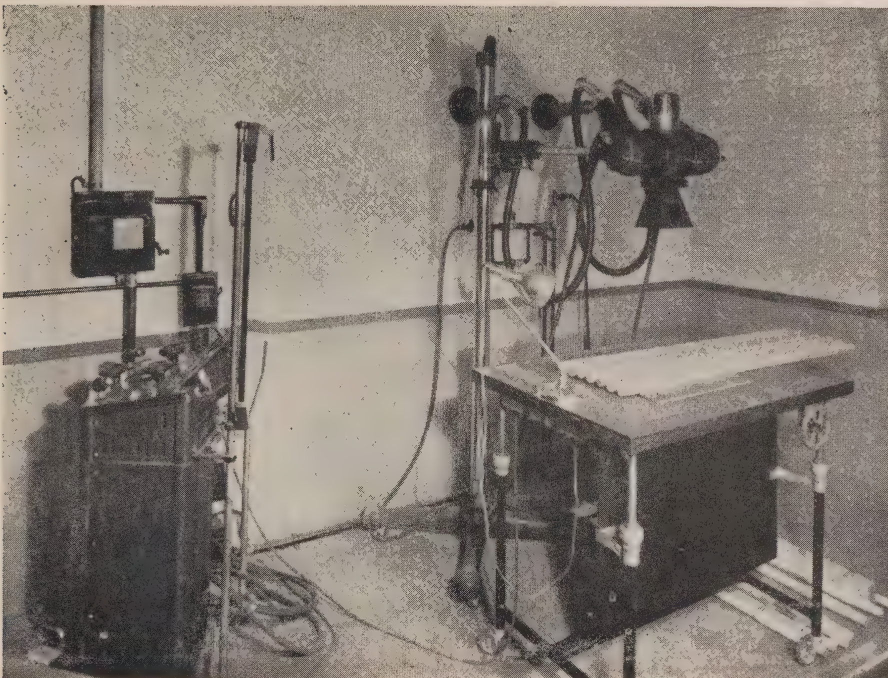


Fig. 1—X-ray unit arranged for taking radiographs of cast aluminum conductor joints.

The unit assembled for fluoroscopic work is shown in Fig. 2. In this case the tube is placed under the table and the X-ray beam directed upward. A rectangular section of the lead table top immediately above the tube is removed and the lead-lined viewing box shown in Fig. 3 is placed over the opening. The X-ray beam, after passing through the subject, in this case a cast aluminum conductor joint, strikes the fluorescent screen. The image produced on the screen is reflected from a mirror so placed that the operator, while viewing, is out of the direct X-ray beam. Further protection from scattered radiation is provided by the sheet of lead glass in the operator's line of vision, the lead lining in the viewing box and the lead apron extending from the table top to the floor.

To facilitate rapid handling, the objects to be inspected by the fluoroscope may be carried under the screen on the trolley conveyor illustrated in Fig. 2. To minimize eye fatigue fluoroscopic examinations are always performed with the room in total darkness. For the same purpose adjustable lead shutters are fastened above the tube cone to cut off the X-ray beam, and thereby extinguish the brilliant glow, from all parts of the screen except those on which the image of the subject appears.

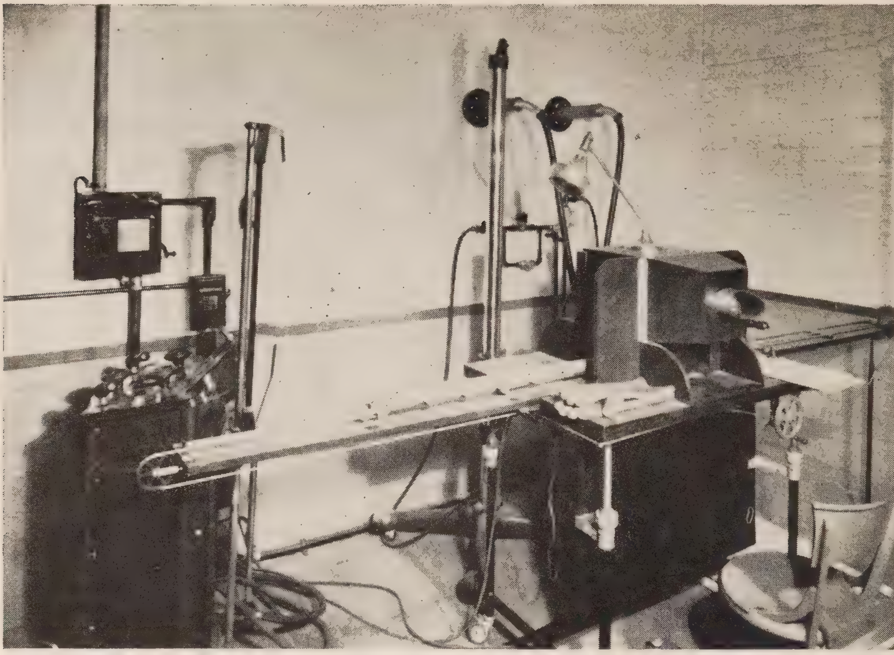
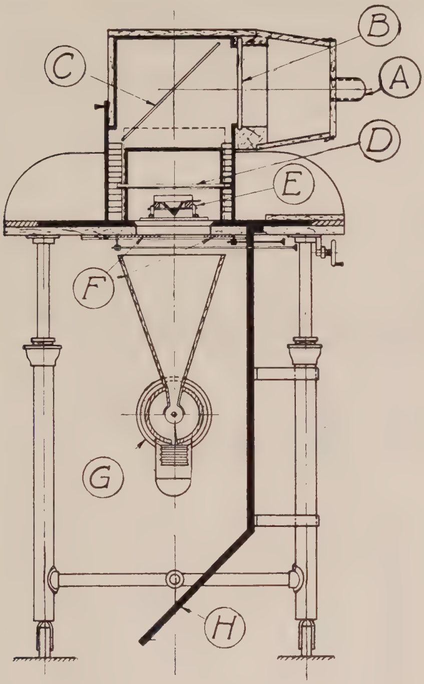


Fig. 2—X-ray unit arranged for making fluoroscopic examinations of cast aluminum conductor joints.

Although fluoroscopy is limited to the examination of parts made from aluminum or light metals, rubber, plastics, wood or very thin sections of steel, such a method, where applicable, has advantages over radiography in speed and economy. It is not as sensitive, however, as the radiographic method in revealing small defects and its sensitivity falls off rapidly where higher voltages are required to penetrate subjects of greater thickness or higher density. In addition, in inspecting by this method, the acceptance or rejection of the piece depends on the momentary judgment of the operator as no permanent X-ray picture is provided for record purposes or further study.

The limitations of any X-ray unit when used for radiographic work depend chiefly on the penetrating power of the radiation which can be produced. As the voltage is raised to the permissible voltage rating of the tube, the wave length of the radiation becomes progressively shorter and its penetrating power increases. For instance, a unit of 75 kvp. rating might be used to X-ray ¼ inch thickness of steel, whereas one of 200 kvp. rating could penetrate 3 inches of the same material.

To obtain, in a radiograph, the best definition and least distortion of the internal defects in the subject, simple geometrical considerations will show that the area of the focal spot in the



A—Viewing hood.
B—Lead glass.
C—Mirror.
D—Fluorescent screen backed by lead glass.
E—Specimen trolley.
F—Movable lead shutters.
G—X-ray tube.
H—Lead apron.

Fig. 3—Cross section of fluoroscopic viewing box.

tube, or the spot from which the X-rays emanate, should be as small as possible and that, during the exposure, the tube should be placed as far as is practicable from the film. For the purpose of eliminating fogging of the film by scattered and secondary radiation, which are always produced when X-rays strike matter, a variety of blocking techniques have been developed using metal shot, lead sheet, barium clay, etc. To increase the range of thicknesses in a subject which can be satisfactorily X-rayed by one exposure, methods, such as building up the thin sections by means of metallic shot or powder, or immersing the whole in a liquid having an equivalent absorption coefficient, are often used.

The thickness of material that can be penetrated at any given voltage depends on its density and atomic weight. Thus, while the Laboratory 150 kvp. unit can readily penetrate 6 inches of wood and 3.5 inches of aluminum, it can only penetrate 1.25 inches of steel and 0.875 inches of copper in a reasonable exposure time.

In the four months during which the Laboratory unit has been operating, some 800 fluoroscopic examinations and a number of radiographs have been made of a new type of cast aluminum conductor joint prior to machining. In the first shipments of these a rather large percentage was rejected for shrinks, blowholes and pinhole porosity. X-ray examinations indicated the desirability of changing the design of the mould. When this was done the number of rejects was reduced to less than three per cent in the later shipments.

Both fluoroscopic and radiographic examinations proved of little value in detecting fine cracks in these castings and other methods were evolved for this purpose. However, examinations of drilled aluminum test blocks of the same thickness as the joints, namely, 1.375 inches, showed that defects as small as 0.10 inch could be detected on the fluorescent screen. In radiographs

of the same test blocks holes less than 0.041 inch in diameter were readily discernible.

In view of the extent to which the successful operation of the Commission's plant and the safety of many of the employees depends on the satisfactory performance of structural parts, the use of this modern tool for laboratory inspection and study of engineering materials should be of great value.

New Pole Specifications

By T. R. Campbell, Manager, Overhead and Underground Division, Northern Electric Co., Montreal, Que., and Chairman, C.E.S.A. Committee on Wood Poles

THE Canadian Engineering Standards Association has completed the standard specifications for Wood Poles they have been working on for some time. These are now obtainable from C.E.S.A., Ottawa, as follows: (Price, 50 cents each).

Specification C-15-A—Eastern White Cedar Poles (Northern White).

Specification C-15-B—Western Red Cedar Poles.

Specification C-15-C—Red, Jack and Lodgepole Pine Poles.

Specification C-15-D—Creosote Treatment for Pine Poles.

These specifications possess one feature that has not been embodied in any specifications previously available and that is that pole classes are designated by numbers instead of letters and, because of the basic principles followed, it has been possible to classify poles so that poles of the same class and length have approximately the same initial strength regardless of species. In times like the present when closest attention is given to selecting poles to meet specific loading conditions, this should be a worthwhile feature. Throughout the preparation of these specifications, it was kept in mind that a product was being dealt with that is manufactured by nature and that the specifications should fit the majority of poles as they grow and not attempt to make the poles fit the specications. The latter method would tend to be wasteful of pole timber by rejecting many serviceable poles and thus add unnecessary costs.

In each specification seven classes are adopted with breaking load assignments as follows:—

Class 1—4,500 pounds.
Class 2—3,700 pounds.
Class 3—3,000 pounds.
Class 4—2,400 pounds.
Class 5—1,900 pounds.
Class 6—1,500 pounds.
Class 7—1,200 pounds.

It will be noted that beginning with Class No. 7, the increase is approximately 25 per cent for each class.

The foregoing table assumes that the load is applied 2 feet from the top

of the pole and that the pole breaks at the ground line.

The formula used to determine ground line circumference:—

$$C=15.59 \sqrt[3]{M/f}$$

in which C is the circumference in inches at the ground line, M is the resisting moment in foot pounds at the ground line (assumed equal to the maximum ground line bending moment—namely, the product of the class breaking load and the lever arm) and f is the ultimate fibre stress in pounds per square inch of the timber. In determining the length of the lever arm, depths of pole settings were assumed consistent with those in general use throughout the country and which had been found from experience to be satisfactory in service. The circumference at 6 feet from butt was obtained by applying to the ground line circumference a correction for the taper between the two points.

Ultimate fibre stress figures used in these specifications, are as follows:

Eastern White Cedar—3,600 lbs. per square inch.

Western Red Cedar—5,600 lbs. per square inch.

Pine—6,000 lbs. per square inch.

In order to make full use of all sound poles and not reject those whose only defect is failure to meet both top and six feet from butt circumference, Classes 8, 9 and 10 are provided, but it is not intended that these will be used for general construction work. There may be occasions when for temporary or unimportant work, the use of a low-priced pole of these classes may be justified.

It is hoped that the Electric Utilities of Canada will find these Pole Specifications valuable.

C.E.S.A. Specifications 51 and 52

Forming Part II of the Canadian Electrical Code

By J. R. Catterall, Testing Engineer, Canadian Engineering Standards Association, Approvals Division, Toronto

Specification C22.2 No. 51
Armoured Cables and Armoured Cords

THIS is a revised edition of the Canadian Engineering Standards Association's Specification covering armoured cables and armoured cords. Electrical contractors and others in the industry are quite familiar with this type of cable and many contractors refer to it as "BX" (the latter being merely one of the trade-names for the material).

There are no radical constructional changes in the cable specified in the new edition, but as the stock of the previous edition (July, 1938) had be-

come exhausted it was decided to prepare a new edition to take care of a number of proposed alterations in the arrangement of the matter, correct a few dimensional values, and clarify the wording of certain requirements. Holders of the July, 1938, edition are advised to furnish themselves with a copy of the new edition if they wish to be right up to date.

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Specification C22.2 No. 52

SERVICE ENTRANCE CABLES

This is an entirely new specification of the Canadian Engineering Standards Association. Service entrance cable is a type of cable which was introduced to the electrical trade by the manufacturers of wires and cables in the United States about six or seven years ago, at the request of public (electrical) utilities, who, in their efforts to promote a more extensive use on the part of householders of electrical appliances — chiefly electric ranges—found themselves handicapped because of the high cost of replacing existing service conduits. These conduits, sufficient for a consumer's ordinary lighting loads, were too small to allow for the larger service cables necessary to supply both light and electric ranges. Public utilities in Canada were faced with the same problem as those in the United States, and Canadian manufacturers of wires and cables responded to the demand for a less expensive form of service entrance.

The fact that this specification has only just been issued does not mean that service entrance cables are only now being used in Canada. The cables have been used in Ontario and in some other parts of Canada for at least four years. Approval was given for the use of these cables under a temporary arrangement "for trial installation", which procedure was first recognized in the 1935 edition of the Canadian Electrical Code, Part I. The issuing of this specification indicates that specific types of cable have now received official recognition by the Committee on Part II of the Canadian Electrical Code and that henceforth the material may be placed on the list of materials approved by the C.E.S.A. (Approvals Division).

The use of the new cable is however not confined to replacements, as it may be used on new work for light, heat and power supplies. Its use is not entirely restricted to that part of a consumer's supply which is attached to a building. Some styles of Type SE cable are sufficiently light in weight yet of sufficient tensile strength to permit of their use from the pole to the building and then down the side of the building (without the use of rigid steel conduit) direct to the meter or other service equipment. In other words, some types of SE cable serve the purpose of a service drop cable in addition to a service entrance cable. All types however may be used merely as substitutes for ordinary rigid steel conduit services provided that the proper fittings are used where the upper end of the cable at the building is attached to the ordinary supply feeders (service drops) from the pole.

Specification C22.2 No. 52 covers two principal types of service entrance cable—Type ASE (armoured

type) and Type SE (unarmoured type).

Type ASE

This type is required to have inherent protection against mechanical injury and a flame-retarding moisture-resisting covering.

The use of Type ASE does not appear to be general, probably because of its greater cost as compared with the Type SE. Type ASE is always circular in cross-section. Its usually solid core consists of insulated conductors with very thoroughly impregnated fillers in the valleys and over the twisted conductors. Over the core and fillers is a heavy armour of formed galvanized steel tape, the tape being wound helically and so shaped that the edges of adjacent turns overlap and interlock,—exactly as in ordinary flexible steel conduit and armoured cable. Over the steel armour there is woven a heavy cotton braid which is then impregnated with weather-resisting and flame-retarding compounds. This type is much too heavy and solid to be used as a service drop cable and where it is used it generally takes the place of a rigid steel conduit service entrance and therefore requires a service head at its upper end—similar to Type F condulet fittings used on rigid steel conduit services.

Type SE

This type is sub-divided into six styles: "U", "A", "UR", "IU", "IA" and "IUR", the general construction of which is as follows:—

Style U—The copper wires forming the uninsulated (neutral) conductor are wound helically over the insulated conductor assembly,—that is, under either the rubber sheath, or the outer fibrous coverings employed in lieu of a rubber sheath (the moisture seal).

Style A—The construction is the same as in Style "U", except that a galvanized, inter-locking, flat steel tape is wound directly over the uninsulated neutral conductor.

Style UR—The construction is the same as in Style "U" except that a number of galvanized steel reinforcing wires are incorporated with the bare copper wires of the uninsulated, neutral conductor.

Style IU—A simple assembly of two, three, or four insulated conductors, twisted together in a standard lay-of-twist—under either a rubber sheath, or the outer fibrous coverings employed in lieu of a rubber sheath (the moisture seal).

Style IA—The construction is the same as Style IU except that a galvanized, non-interlocking, flat steel tape is wound directly over the conductor assembly.

Style IUR—The construction is the same as Style IU except that steel reinforcing wires are wound helically over the insulated conductor assembly.

The first three styles of Type SE cable embody an uninsulated neutral conductor in the assembly of conductors. The last three styles have all conductors insulated.

Styles "A" and "IA" of Types SE cable are often referred to as "armoured types of service entrance cable". This is unfortunately the cause of much misunderstanding on the part of electrical inspectors, electrical contractors and others. The

only "armoured" service entrance cable covered by this specification is Type ASE, the construction of which has been previously described. Confusion would be avoided if styles "A" and "IA" of Type SE cable were referred to by some other term than "armoured": the flat steel tape, as used in these two styles and which is wound spirally over the conductor assembly and does not interlock as in the case of the tape on Type ASE, is not recognized as an armouring because it is considered to afford practically no resistance to impact. Perhaps the confusion referred to above arose from the unfortunate adoption of the style letter "A" used to distinguish these two styles from the others.

Rule 402 (f), sub-clause 4 (i) of the 1939 edition of the Canadian Electrical Code will permit the use of Type ASE cable on side walls of buildings without additional protection against mechanical injury because of the fact that the interlocking steel armour is considered to afford this protection; sub-clause 4(ii) requires that Type SE cable shall be protected by conduit or other approved means where installed within 7 ft. of the ground or where subject to mechanical disturbances,—such as might occur near awnings, window-shutters, swinging signs, etc. It should here be mentioned that when the 1939 edition of the C.E. Code, Part I, was being drafted only three styles of Type SE cable were planned —"A", "U", and "UR"; the other three styles "IU", "IA" and "IUR" were added to this specification at a later date.

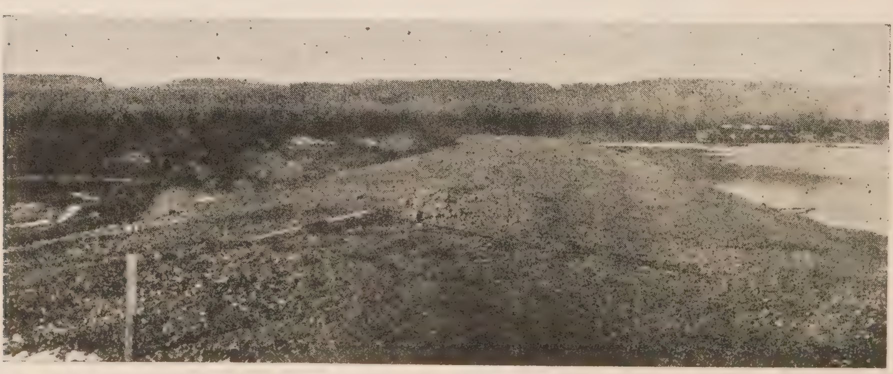
The maximum working voltage for which the cables are rated is as follows:

Type ASE: all conductors insulated—600 volts; one conductor uninsulated—150 volts to ground.

Type SE: all conductors insulated—300 volts; one conductor uninsulated—150 volts to ground.

* * * *

Copies of these standards may be obtained from the Canadian Engineering Standards Association, National Research Building, Ottawa, price 50 cents each.



Aluminum

By R. E. Powell, President, Aluminum Company of Canada, Limited, Montreal

ALUMINUM is not a mixture or combination of other metals. It is one of the elements — the same as iron, copper or gold. It is not expensive. It is easily worked. It resists corrosion. When alloyed, it is as strong as mild steel. It weighs only one-third as much as iron. These qualities help to explain the selection of aluminum and its alloys as the materials best suited for so many things, including numerous and important parts of modern aircraft.

The war effort of the aluminum industry may be understood more quickly if the industry is considered to have two principal parts.

Firstly, there is the production of crude aluminum by chemical and electrolytic processes, the ore for which is bauxite—and, practically speaking, bauxite is obtainable only in tropical and sub-tropical countries.

Secondly, there is the primary fabrication or conversion of the crude metal into castings, plates, sheets, tubes, rods, forgings, structural shapes and the many other forms needed by those who manufacture such things as aircraft.

When the Germans planned this war, they apparently decided that overwhelming superiority in the air would bring about the speedy collapse of the countries they wanted to dominate, absorb or destroy — and that meant more and more modern aircraft, which are approximately 75 per cent. aluminum. Isn't it reasonable to assume, therefore, that the Germans didn't start the war until they believed themselves to be superior in aluminum? Be that as it may, Germany produced more aluminum in 1938 and 1939 than any other country and, in addition, Germany imported substantial quantities of the metal. And, what is equally important, Germany equipped itself to cast, roll, extrude, forge and otherwise convert all of its huge supply into the parts needed for its fleet of the air. How did Germany do this? It was done by people enslaved to prepare for conquest—a people denied even adequate food and clothing that more money might be available for war.

The fact that Canada and other democracies found themselves unprepared for the kind of war forced upon them is proof positive that they wanted and expected peace. Certainly Canadians had no thought of attack against other peoples. We wanted to be left alone and to use our resources and energies to produce for the benefit of the people—and not for their destruction.

Conquests Aided Nazis

When the Germans invaded Poland, the production of aluminum in Canada was exceeded by the production in Germany but the Canadian production was the result of 40 years of

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Radio address broadcast by the Canadian Broadcasting Corporation on March 30th, 1941.

effort uninfluenced by thoughts of war, except, of course, during the four years of the first World War. The superior position of the Germans was improved by their conquest of Norway and France, both important producers of aluminum but, even before the fall of those unhappy countries, expansion in Canada was well under way. In only 11 months the Canadian industry more than doubled the capacity developed during the 40 years preceding the war—and the capacity continues to soar.

Measured by cubic feet, the volume of aluminum now being produced in Canada is greater than the volume of any other metal produced in this country, except iron, and it is enough to make more than 50,000 planes annually.

The United States and Canada together produce more aluminum than the rest of the world.

Only in Norway is the per capita power generation greater than in Canada and yet ⅙ of all the electrical energy generated in this great Dominion will very soon be used to make aluminum—and that is twice as much electricity as is used in all of the homes throughout the whole of Canada. With only a small market for aluminum and with practically none of the raw materials needed for its production, Power, then, is the explanation of the magnitude of the Canadian aluminum industry.

To make the greatest possible amount available for war, Canadian aluminum is no longer sold for anything not urgently needed by the armed forces of the United Kingdom, Canada and their Allies. Factories no longer make such things as aluminum cooking utensils, foils, wire, paint pigment and radio parts and in Hamilton, Toronto, Valleyfield, Montreal, Three Rivers, Shawinigan Falls and other Canadian cities and towns factory owners and employees have willingly sacrificed their established businesses and trades—all in the common interest of winning the war.

Surplus Sent Abroad

During the years past, Canada's consumption of crude aluminum seldom exceeded 10 per cent of its production. The surplus was exported, principally in crude form for the reason that users of the metal in other countries required local fabricating facilities — and tariffs and other forms of nationalism in those countries did not help Canada to sell for export except in crude form. In 1938 the foreign business came from 59 countries and brought to Canada foreign exchange having a value of $24,000,000.

Before the war, Canada's fabricating facilities, more than sufficient for its home market, were used to convert metal for manufacture of articles wanted by peaceful peoples and, as a result, the country was not well equipped to convert aluminum and its alloys into the forms needed for modern war.

But since the fateful September of 1939, fabricating and conversion plants in Toronto, Montreal and elsewhere have been improved and diverted to work for war, and huge new establishments have been built, equipped and put into operation so that this country is now able to deliver

aluminum in all of the forms required for the construction of all kinds of war planes—and in quantities amazingly large.

Although the rapid and substantial expansion cost a very large sum of money, the Governments of the United Kingdom, Canada and their Allies are now able to buy Canadian aluminum at prices less than those current at the beginning of the war and that is largely because aluminum workers have so patriotically and enthusiastically devoted themselves to their share of national service.

The men — some sweltering in tropical bauxite mines, some shivering as they dam a wind-swept northern river—have resisted their natural wish to join the armed forces. To them is given the stern task of forging the weapons for others to use—almost endless toil without glory. They and the contractors who have collaborated with them have indeed accomplished marvels. To be fully appreciated, their accomplishments should be even better known.

As an example, urgent and important problems caused one engineer to fly thousands of miles to visit two tropical countries to help with the design and construction of docks, railway bridges and other bauxite facilities now being created there by Canadians and, almost before anyone realized that he had gone, he returned only to find another problem at a new aluminum power development in northern Quebec, almost 200 miles from the nearest habitation. Practically speaking, he stepped from one 'plane to another, from the Tropics to the sub-Arctic.

Men and horses, tractors and trucks, food and cement and everything else required for the new power development had to be transported by plane. The total freight so carried was greater than that of any other air freight contract in Canada's history.

Greenland a Key Point

Cryolite, essential for the production of aluminum, occurs only in Greenland, a Danish colony almost within sight of Canada. Invasion of Denmark jeopardized the supply of that essential material. Within a few hours after the invasion of Denmark was known in Canada, representatives of the Dominion Government and of the aluminum industry began co-operative effort which subsequently took the form of an expedition to Greenand largely for the purpose of insuring adequate supplies of cryolite for British aluminum production. Food, clothing and other necessities of life were also sent to Greenlanders, so precipitously detached from their homeland. More and more, Greenland is turning toward Canada as a source of all supplies.

Ships to transport raw materials and aluminum have been acquired. Some have been lost—but others are being found and everything kept moving.

And so the work goes on and will go on until victory is won. Canadian engineers and geologists, doctors and nurses, teachers and priests, accountants and builders, welders and carpenters—yes, labourers representing every degree of energy of mind and muscle—are working from the trop-

ics to the sub-Arctic—all inspired with the knowledge that they are helping to produce the aluminum needed to win this war.

Within its field, then, the aluminum industry is providing the tools of war—and it will help Mr. Churchill to "finish the job."—*La Sentinelle.*

War Research—An Engineering Problem

By Dean C. J. Mackenzie, M.E.I.C., Acting President, National Research Council of Canada, Ottawa, Ont.

I PROPOSE to speak to-night about science and war; of the part science has played in the preparation for and is now playing in the conduct of the present conflict.

Mr. Winston Churchill, reviewing the first year of war in Parliament on August 20th, 1940, drew attention to the fundamental difference between the war of 1914-18 which he described as a "war of men and shells" and the present one which he described as "a conflict of strategy, of organization, of technical apparatus of science, mechanics and morale."

Of the great importance of strategy and morale, there can be no question but I will discuss only the organization and relationship of science to technical apparatus and mechanics of war.

In referring to science, I use the word in its generic sense, not as something apart from its application to operations and industry but as one activity extending from the highly specialized research worker in the laboratory through the stages of engineering development and industrial production to maintenance and military operations in the field.

Of two things I am convinced: (1) That the British Empire to-day is superior to Germany in scientific and technical matters, which was not the case in 1914; (2) That while dictatorships may have some advantages over democracies in the political, financial and economic control of a nation, the same cannot be said of its scientific activities. These two generalizations, if true, are deeply significant, for it can be easily maintained that modern wars are not a matter of "men and shells" but largely of scientific development, mechanics, technical apparatus, and organization—in other words, applied science or engineering. If democracies can mobilize the resources of science as effectively in war as can the dictatorships, there should be no doubt as to the final results of this war, and if the scientific philosophy and techniques can make a nation victorious in war, there should be little difficulty

Radio address broadcast by the Canadian Broadcasting Corporation and sponsored by the Engineering Institute of Canada, October 23rd, 1940.

in the peace to follow unless the future leaders of democracies fail to appreciate clearly what are proving to be the fundamental structural elements of a modern industrial nation.

What is the fundamental measure of a nation's status as a scientific and industrial state? At the risk of oversimplification, I suggest it is the degree to which mechanical power has been substituted for human labour. The idea is not new—the evidence is apparent everywhere; the implications of this movement, however, have never, I think, been appreciated in advance. The substitution of mechanical power has been taking place at an ever-accelerated pace since the 18th century; it is still going on. We see around us everywhere changes brought about in the past; we admit in principle but rarely envisage realistically how great will be the future changes. In no field is this more apparent than in war.

When wars descend upon us, the public is inclined to be critical of those in responsible control, but I think it only fair to our military leaders to admit that, for the last 15 years at least, thoughtful staff officers of the forces in Canada and England have been prophesying what Mr. Churchill, on August 20th, stated as a current fact—that the war of to-day would be not one of "men" but of machines, that the front line would run through the factories, and that scientific planning, technical equipment, and industrial production would be prime factors. The scientific and technical officers of the military forces and civil establishments in England, I suggest, are not responsible for the difficulties we are experiencing to-day but they are largely responsible for our greatest blessing that, plane for plane, our Air Force is superior to the much-vaunted German machine.

It has been stated that in the old Canadian Corps of 1918, the horsepower of all the mechanical equipment was probably less than 50,000, while to-day a modern Corps of four divisions has about 1,000,000 horsepower incorporated in innumerable vehicles, trucks, tanks and carriages. If, for illustration, we accept the estimate that it takes ten men to perform the work of one horsepower in a machine, we see the modern corps, equipped with an increased effective energy capacity equal to that of nearly 10,000,000 additional men. This comparison, of course, must not be pursued too literally but the implications are obvious: in 1914 all army officers were supposed to know something of horsemanship and be able to ride. To-day such officers must be able to drive a truck, ride a motor-cycle and know something of internal combustion engines.

The tank corps, with their mechanical horses, have made cavalry obsolete, and the pilot of a fighter and the air crew of the bomber, control and direct greater forces of power than did many a brigadier-general in 1918. When we realize the extent of army mechanization, the number of high-powered planes, the masses of artillery and tanks with which a modern nation in arms must be equipped, we begin to appreciate that the war of to-day bears about the same relationship to past wars (even that

of 25 years ago) as does a modern mass-production industry to a simple cottage industry of the 17th century. This, of course, means more and more scientific, engineering and technical training; relatively fewer men in service units but more highly trained and elaborately equipped.

When Mr. Churchill said, "Never in the field of human conflict was so much owed by so many to so few," he paid a tribute to the most gallant band of heroes of the air and the sea that the world has ever known and we all say, "Aye", but a tribute was also paid at the same time to the relatively few scientists and engineers both of the fighting services and civilian establishments who, through 20 years, while the democracies were bathing listlessly in the enervating philosophy of disarmament and appeasement, were quietly developing machines and equipment as superior in quality as the youths who now operate them.

It is, of course, not permissible to discuss scientific research and developments that have matured or are under way but something can be told of how such work is organized and carried out.

England in 1914 was not organized scientifically; there were, of course, many eminent scientists of world renown and the standards of applied science and engineering were high but there was no co-ordinating agency such as German had had for years, nobody whose duty it was to organize, support and correlate the activities of the numerous laboratories and workers of the nation. When war broke out in 1914 this handicap was quickly recognized and a government Department of Scientific and Industrial Research was set up for this purpose and increasingly generous support for both civil and military research has been given ever since, with the result that to-day in this respect the advantage is not on the side of Germany.

In addition to the civil Department of Scientific and Industrial Research in England, the Navy, the Army and the Air Force all support research institutions, under the necessary conditions of military secrecy and discipline, and manned by highly qualified scientists, both of civilian and military rank. Unfortunately, scientists and engineers working in such stations cannot, of necessity, publish the results of their work and the public knows, and can know, little of their accomplishments, but events are gradually disclosing the extraordinary value of their activities during the past decade, and I think it will be an eternal credit to the wisdom and far-sightedness of responsible officers of the services that during all those depressing days of disarmament and cutting of military budgets they continued to spend larger and larger proportions of their shrinking revenues on scientific research, development, design and planning. The results are now becoming apparent. The Royal Navy is maintaining its ancient level of technical excellence. The youngest of the services, while lacking numbers is superior, man for man, plane for plane. The magnetic mine was quickly mastered by superior scientific application and the scientific and technical equipment and

aids for the three services have proved to be second to none.

To me a fact of the greatest significance is that in the Empire scheme of scientific organization, there is an unusually intimate integration of the efforts of civilian and military scientists, civilian and military engineers and industrial establishments in the production and use of apparatus, equipment and supplies for war. In Engand, many eminent university scientists have worked as volunteers for years in close co-operation with the services and now are seconded to research stations. Many scientists who, until a few years ago, were interested only in problems of fundamental research of no immediate application, under the stimulus of national peril, have become feverishly interested in direct application and some of the finest engineering design and development is being done by such men. Today, both in Canada and England, the vital stress is on application. The line between pure and applied science has become obliterated. Scientific research is an engineering problem because if developments have no chance of ending up in industrial production and effective tactical use in the field, no scientist engaged in war work is interested. The pure scientist becomes an engineer overnight. It is not a matter of different techniques but a matter of nearness of objective. Long-term fundamental research is for times of peace. In a war for survival we live on our capital and work for today.

In 1916, following England's example, Canada also established a National Research Council for the purpose of organizing and co-ordinating scientific and industrial research in Canada. Through the generous support of successive governments, this institution has grown, at first slowly, but since the laboratories in Ottawa were opened in 1932, expansion has been rapid. Until war broke out, the stress was naturally on problems concerned with peace-time activities but today the reverse is true, and the activities of a staff doubled in number, are devoted almost exclusively to problems having a war bearing.

In Canada there has developed an association between the National Research Council and the services of the Department of National Defence which it is generally conceded is most effective in our war effort. There is an intimate contact between the technical staff of the Council and the scientifically-trained officers of the three services (and there are many highly trained scientists in uniform), and the National Research Laboratories are functioning as scientific research stations for all of the services. The Department of National Defence and the Department of Munitions and Supply use the Research Council much as the large industries use their affiliated research and engineering institutions. The quality of army supplies are today carefully guarded by the departments concerned; changes in specifications, substitutes or new developments are referred to scientific experts and laboratories and scientific tests have now more weight than personal opinion.

There is a growing amount of research and development work going on in the fields of aeronautics,

physics, chemistry and electrical engineering and with the active steps being taken for the direct defense of our own shores, the demands for more and more scientific research and development work in Canada will increase. That Canadian institutions can and will meet such demands, is admitted by all; that the integration of the efforts of the pure and applied scientist, the military and civilian technologist, the engineer and the manufacturer is making for the most effective contribution in Canada, there can be no doubt; that scientific research in wartime has become an engineering problem no one can question.—*The Engineering Journal.*

The Electrical Industries of Canada and the War Effort

By John R. Read, President, Canadian Westinghouse Company, Limited, Hamilton, Ont.

IN speaking to his people, His Majesty, the King, used the now-familiar words: "This time, we're all in the front line."

"The great task of this day," said President Roosevelt in a recent address, "the deep duty which rests upon us, is to move products from the assembly lines of our factories to the battle lines of democracy—NOW. The light of democracy must be kept burning."

In the struggle to keep alight the torch of democracy, eventually to make it shine stronger and brighter than ever before, the electrical industries of Canada,—power, apparatus, and communications—are playing a vital role.

At the time of Julius Caesar, the money cost of war death, the cost per soldier killed, is estimated to have been about fifty dollars. At the time of the Battle of Waterloo, this cost had climbed to about five thousand dollars. In this war, the cost per soldier killed has been estimated at about two hundred thousand dollars.

That demonstrates the real meaning of the phrase to which we've become so accustomed in recent months, that this is a mechanized war.

In hundreds of Canadian factories, the tools of victory are now being forged at an ever-increasing pace. But behind every phase of the war effort you will find some aspect of the giant Canadian electrical industry.

The Canadian worker has more electrical energy at his elbow than anybody else in the world, with the exception of the Norwegian. Each Canadian has almost six times more electrical power than the American to help him do his work.

Over 80 per cent of the power used for all purposes in Canada is electric power. Canada has been wonderfully

Address radio broadcast by the Canadian Broadcasting Corporation on April 3rd, 1941.

blessed with water power resources. To-day the electrical plants of the Dominion can produce over nine million horsepower. That is more than five times the amount of electric power available for Canadian industry in the first Great War.

Most uses of electric power are very familiar, but here are just a few examples of what that vast and increasing supply of low-cost electrical power means to Canada's war effort.

Enormous supplies of power and power equipment are required in the manufacture of explosives. Because Canada has the power available, this country is now investing one hundred and six million dollars in creating great chemical and munitions plants in various parts of the country. These will be a sure and, above all, a safe source of supply for the cause of democracy everywhere.

Aluminum is a key war metal. It is required in the manufacture of airplanes, and in a hundred other places in the machinery of war.

To make aluminum, very large amounts of electricity are required. Hitler's successes on the continent of Europe closed off Britain's major source of aluminum. Most of her supplies formerly came from Norway because Norway had great supplies of electric power. For the present time at least, Britain can get no more from that source. In recent months, British housewives have been cheerfully turning in their pots and pans to help meet Britain's urgent need.

But in order to provide Britain with adequate supplies of aluminum, to make absolutely sure that she'll never want for a single pound of the white metal, a big new aluminum plant is now being constructed in Canada.

Canada is doing this job because this country has a great supply of convenient electric power. This new plant represents an investment of about fifty million dollars. When completed, it will produce enough aluminum a year for the construction of around fifty thousand military airplanes.

In order to get the plant into operation as swiftly as possible, some parts of the Canadian electrical apparatus industry worked twenty-four hours a day to produce electrical conversion equipment—machinery that had never before been made in this country. This will be an installation of seven hundred thousand horsepower.

That is just one example of how a big and efficient industry, doing a peacetime job, also serves the war effort.

It is much the same story with respect to all those other metals, vital in war, key factors in making Canada's contribution to victory great: gold, copper, nickel, lead and zinc. Almost one-tenth of all the electrical power used in Canada is employed by the mining industry. Ample power supplies have made it possible for the mines to increase their production to meet war needs. Electricity and electrical equipment are involved in almost every phase of mining and metallurgy.

But the generation of electrical energy is just one part of the electrical industry's war effort. Power has to be harnessed, brought to bear,

directed. Canadian manufacturing plants and Canadian workers turn out some of the largest generators and water turbines made anywhere in the world,—giants of 500 tons—machines that harness rivers and subdue them.

Every shell, every gun, every tank, every airplane, every single piece of war equipment also involves the electrical industry. For beside every machine tool, and remember there are tens of thousands of separate operations, there must be an electric motor, large or small. And beyond the motor, there must be wires and transformers, switches and generators.

To meet the swift and compelling demands for more and more equipment, new power resources are now being harnessed, more power's being produced and large supplies of additional electrical equipment are needed to convert this power into the tools of victory.

But war ADDS to the service which the electrical industry can perform. Because of its highly skilled workers, because of its wide diversity of machine tools and equipment, the electrical industry has been assigned many direct war tasks.

The most notable special undertaking by the Canadian electrical apparatus companies is the manufacture of anti-aircraft guns for armies and navies, great big guns with barrels over fifteen feet long. Until a few months ago, Canadian industry knew hardly anything about making modern artillery. Today, several Canadian firms are into production and doing a very efficient job.

The electrical plants are also making some very secret types of war equipment. I must not give you details of these things now, but I know that when the war is over, and the story can be told, you will be surprised—and I think I may say proud—that these extraordinary and very important devices were being turned out in our own country by our own workmen to help in the Battle of Britain.

One of the very striking differences in equipment between this war and the last relates to communications. The course of this war, and every war in history, clearly reveals the importance of a constant flow of information between headquarters and the fighting units. Since the first Great War, the whole new world of radio has emerged, and radio equipment makes possible the constant co-ordination of military action.

Radio is also a vital link in the national life as a medium for the exchange of information and ideas, for binding the country together in common understanding, sentiment and aims.

There's another device which we hope will prove very efficient in driving back, and in shooting down Nazi night raiders thereby saving thousands of civilian lives. Military officials in Britain have said that this device promises to LICK night bombing. The Canadian electrical industry is now engaged in manufacturing this remarkable instrument.

Electrical scientists have also developed the device that guards ships against mines and submarines, and which has rendered useless the magnetic mines that Mr. Hitler concocted,

hoping that this new instrument of destruction would make possible the sinking of the British fleet and invasion of the British Isles.

The electrical industries have always done a great deal of research. The development of the new and the better has been the keynote of their existence and growth. This activity's been intensified by the war. Already scientists of the industry have moved far in the fields of television, facsimile, electron optics and in the fields of extremely high frequencies. Achievements in these fields so far indicate that in the future more amazing things will be developed and brought into common use than in the past. Developments in this field are now being rushed because of the important, and probably decisive, contribution they will make to defense and to victory.

Cable and telephone communications, another branch of the electrical industry, have their vital role, too. They have done a splendid job in meeting the tremendous demand for additional telephones and telegraph facilities resulting from all this war activity.

And there is that other branch of communication, the street railway systems, providing low-cost transportation for Canadians. And while thousands of Canadian workers drive their own cars to work, the street cars of Canada carry over six hundred million Canadians a year.

More than sixty thousand Canadians are engaged in some part of the whole electrical industry. Their wages and salaries amount to over one hundred and ten million dollars a year.

The electrical industry of Canada well realizes the task which war imposes, the duty which it owes to democracy, to Canada, and to the ideals of its founders—men like Edison, Westinghouse, Alexander Graham Bell, Marconi and others.

Not only must the electrical industry continue to supply essential peacetime needs. It must also, as a war volunteer, produce important weapons of war in vast quantity and with speed.

Our industry has always employed large staffs of highly trained engineers and scientists, and we have lent many of these to the government, the army, the navy and the airforce for work that must be done.

Ladies and gentlemen, we are doing our best to be good soldiers, to be among the shock troops of the industrial front.

"The light of democracy must be kept burning."

How Progress is Made in Engineering

THERE may be said to be two kinds of engineering, that which is essentially creative, and that which is practiced in pursuit of known methods.

Of these two types of engineering, the latter is much the most common, and through its systematic pursuit, great productions may be and are accomplished. There are many well-educated and trained men who can be depended upon to work with accuracy and fidelity, and good organization can direct their efforts to workable and dependable results.

The tendency of humanity is to be satisfied with what it has, and most engineering is looked upon as good or even wonderful. But in reality, most of it is in many respects bad and vastly cheaper, and better methods lay just around the corner when it was being designed.

Great successes may be accomplished by systematic and well-organized adhesion to the stereotyped method, but in the long run engineering enterprise cannot be successful unless it is progressive. To be really successful, we must sometimes lead, not always follow.

This thought leads us to consider what progress is. Our politicians, amply backed by votes, seem generally to be of the opinion that to be progressive is to make all human activity dependent upon collective thinking and planning rather than upon what has for centuries been the aim of people who considered themselves progressives and liberals, namely, that the maximum possible scope and independence should be won away from governments and politicians and given to individuals.

This apparent conflict of ideas has a very definite relation to the practice of engineering. All collective activities to be effective must be governed by discipline. The writer was trained to discipline, knows how to be subordinate, and knows its necessity in many organized activities, but, through experience in engineering industry, he believes that the less discipline has to be applied, the better and more progressive will be the results.

Real thinking cannot be done by groups of people; it can be done only by individuals. Much of the work of the world can be done by rule without much thought, but constructive engineering requires thought, not only in generalization, but, if success is expected, in every minute detail. Engineering is to a very large extent dependent upon detail, and, unfortunately, it is only a very small proportion of humanity who, by training or by temperament, can have the interest in detail which is essential to progressive engineering. Most people are interested in people, not in things.

While much knowledge which has never been really used can be found in books, little that is there is good enough or complete enough to be a

sure guide to the creative engineer. He must be certain of the detail or else he will constantly waste time and money through half knowledge or misconceptions of such knowledge as has been recorded.

There is only one sure way to get at the exact knowledge needed for new surroundings, namely, experimentation.

There are many accomplished experts and specialists in engineering and in science who have never been experimenters, but it is safe to say that almost every man who has enriched the world by applying new knowledge to productive purposes has been an experimenter.

Even great scientists whose minds are stored with accurate knowledge of the records must generally be experimenters if they would make their knowledge available for safe industrial use. Making knowledge so available is engineering.

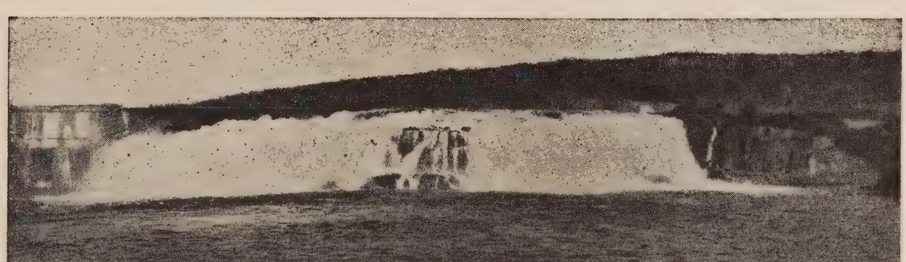
When Langmuir, with his wide knowledge of scientific laws, wrote a formula for a gas-filled lamp, it is safe to say that that formula, while based on sound theory, was amply supported by experimentation.

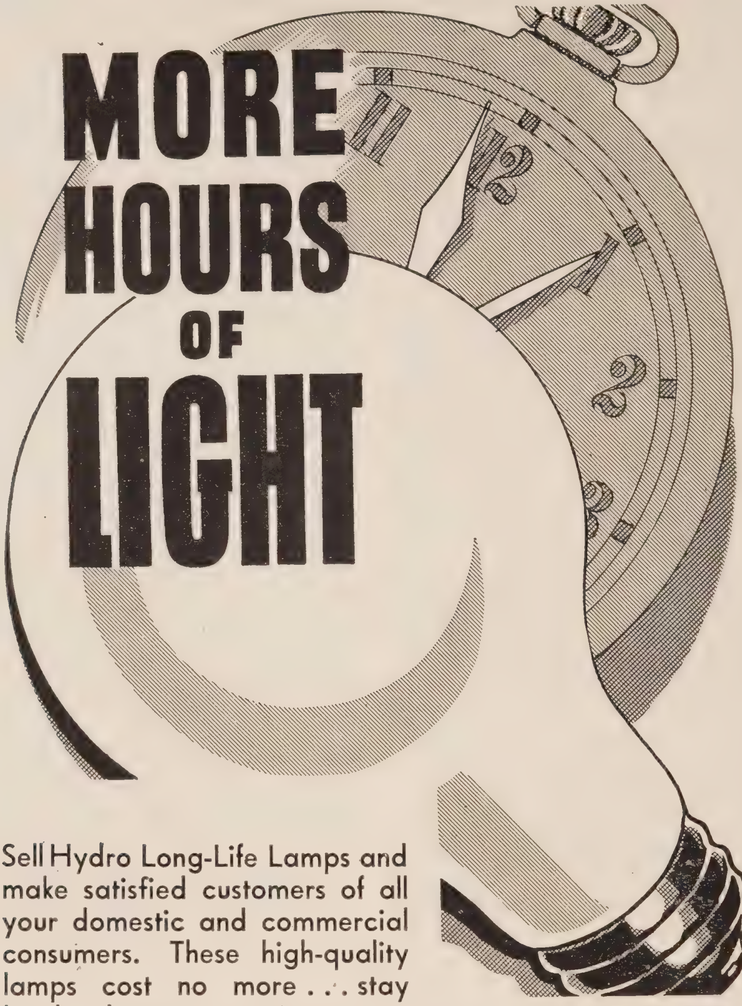
The moral of all this is that if we would be really progressive, we must arrange to give great scope to individuals and must work through them and not through dependence upon organization.

For these reasons, the part of good leadership in engineering is to force responsibility upon individuals as long as they show ability to successfully bear it, but to trust no one to an extent which may endanger or delay the general result sought.

The all-important word to the engineer is WHY and it is astonishing how few people in the ordinary pursuits of human affairs ever think it worth while to trouble themselves about that question, or to make much effort to find out whether the answers suggested will bear analysis.

The good engineer must know the reason why, and will strive day and night to continue to experiment until he gets some adequate answer. To always do so is the best advice which can be given to an engineer.—*Extract from the book THE AUTOBIOGRAPHY OF AN ENGINEER, by W. L. R. Emmet in General Electric Review.*





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Canadians and the War

By Dr. Thomas H. Hogg, Chairman and Chief Engineer, The Hydro-Electric Power Commission of Ontario

AS we sit here in this comfortable room, we cannot forget that our ability to do this in freedom, our ability to go and come as we wish and, within reason, to do and say what we wish, rests today upon the fact that in her island fortress British airmen have been able to hold their own, and on the seven seas the British navy is still effective master.

When Mr. Churchill said, "Never in the field of human conflict was so much owed by so many to so few", he was referring particularly to the Royal Air Force and its magnificent defence of Great Britain. But this tribute of the British Prime Minister has also been well earned by those engineers and scientists, both of the fighting services and in civil engineering establishments, who, frequently against active opposition, or at best under an apathetic asquiescence, have, during the past twenty years or more, laboured, so that in the day of trial Britain's sword was still able to function effectively. For many years past conscientious engineers and scientists, aided by the more far-sighted staff of officers of the naval and military forces of Britain, have been quietly but effectively developing machines and equipment that individually have proved themselves superior to those of our enemy.

In my brief talk today it is, therefore, inevitable I should discuss Canada's war effort and the place and function of Canadian engineers in this—the most important business of the nation today.

Canada's Resources

First I would suggest that we must neither overrate nor underrate Canada's ability to make an important contribution to the Empire's war effort.

Address delivered by Dr. Hogg as President of the E.I.C. on the occasion of the joint banquet at Calgary, celebrating the signing of a co-operative agreement between the Association of Professional Engineers and the Engineering Institute of Canada, on December 14th, 1940.

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MAY, 1941

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

Although a nation of only 11½ million people, Canada's capacity to help is greatly in excess of that which might be surmised from the relative size of its population. It is probably at least twice as great as that of an equal European population, provided corresponding efforts and sacrifices are made. This is due mainly to two things: first—Canada's immense natural resources; and second—the up-to-date character of its equipment for making the most effective and speedy use of these resources.

The fundamental measure of a nation's status as a scientific and industrial state is the degree to which mechanical power has been substituted for human labour. One of the most important items of Canada's modern equipment is the ample supplies of low-cost hydro-electric power available in all provinces. This is evident from the statistical record showing the power used per capita in Canada which, in some measure, is a gauge of the nation's industrial capacity. In 1914 the hydraulic turbine horsepower installed in Canada was less than 2 million horsepower. By 1918 this had risen to 2⅓ million horsepower; by 1940 8½ million horsepower was installed, and of this nearly 7¾ million horsepower was utilized in central electric station industry.

There is now available in Canada more than 4 times the amount of electric power that was available in 1918 at the end of the last war.

Much of the increase in power utilization has been devoted to the production of the raw materials of industry, and many of these are of great strategic importance to war demands. This increased production is particularly noticeable in non-ferrous metals. Since 1914 copper production has risen from 76 to 607 million pounds per year—a 9-fold increase. Zinc production was quite small in 1914, but it is now nearly 400 million pounds—a 60-fold increase—making Canada the third largest world producer. Nickel production has risen from 47 to 227 million pounds—a 5-fold increase. All these metals are of great significance in munitions production.

Canada has no known commercial deposits of aluminum ore, bauxite, but its water powers situated near tidewater have been put to good use in developing, from ore imported from British sources, a large aluminum industry. Since 1914, the production of

aluminum in Canada has increased immensely—and today, Canada's entire production of this vital war metal is under contract to the British Government.

There is no need to continue a catalogue of advances in mineral production. Other war minerals being produced in useful quantities in Canada include lead, now 10 times the average output of the 1915-18 war years—as well as platinum, cobalt, molybdenum, asbestos, and mica.

Canada has made great strides industrially since the last war. In 1914 Canada was only just beginning to feel its strength in industrial and manufacturing facilities. It was still largely an agricultural country. At the outbreak of the present war the total capital value of industrial plant was approaching 4½ billion dollars, about 3 times the total capital value in 1914. We have not only trebled our manufacturing facilities since the last war but we have immensely improved their productive efficiency. If it is true, as Prime Minister Churchill stated, that under modern war conditions "the front line runs through the factories", Canada is in an immensely better position than it was in 1914 to lend effective front-line aid to the Empire cause.

The increase in our total population, amounting to about 40 per cent since 1914, conveys no adequate impression of our industrial growth. There is, however, one very important feature of this great industrial growth which must be recognized, and that is that this rapidly-developed and up-to-date productive capacity was devoted almost exclusively to the purposes of peaceful growth. In 1914 the situation was similar but on a smaller scale, yet we were able to divert our material and mechanical resources into the channels of war production in an effective way. With the necessary determination the same effort can be and is being made today.

But we must be sure that our energies are not dissipated by an enthusiastic extension in certain lines of endeavour which would be out of balance with our ability to produce the more essential war needs. There are certain handicaps or bottlenecks in Canada's industrial set-up for producing munitions and war supplies which must be eradicated. One of the most serious is the deficiency of our machine tool industry—upon which, of course, production in all manufacturing plants is dependent. It is a relatively simple matter to construct a large number of army huts, but the production of precision machine tools, jigs and gauges is a very different matter. This handicap is now being rapidly overcome and fortunately we have been able to call upon the great machine tool industry of the United States, whose help has been a wartime asset of great importance.

Personnel Problem

Another impediment to the acceleration of our industrial war effort may be the difficulty of securing skilled personnel for the new armament plants and for the enlarged operations of existing industrial plants now being adapted to munitions manufacture.

The personnel required in these plants may be considered as consisting of three groups: first, the professionally-trained engineers and administrators; second, the highly skilled draughts-

men, and the artisans who belong definitely to trade groups, such as toolmakers, fitters, pattern makers, carpenters, etc.; and third, the semi-skilled and unskilled workers. Although shortages may develop in all of these groups, it is only in the second group that an acute shortage is regarded as a probability.

This whole problem, however, is one which I believe The Engineering Institute of Canada and the Professional Engineering Associations will help to solve.

The possibility of this problem developing was recognized even before war was declared and the Canadian engineering organizations, at the request of the Department of National Defence, made a notable contribution by gathering together the academic and professional records of approximately 10,000 engineers and technically-trained men. This voluntary census, completely indexed and filed, is now of considerable help in locating technical men competent to fill deficiencies in the first group, and also to some extent in the second group. The Engineering Institute of Canada, with its wide knowledge of the profession, is taking a prominent part in this valuable service, by finding the right type of engineer when asked by the various government departments and those firms carrying out special war contracts.

With regard to the third group of semi-skilled and unskilled workers, it is not anticipated that there will be any serious difficulty. In this class of semi-skilled workers are included those who have had some industrial experience, for example in operating automatic machinery or in working on an assembly line. As is well known to industrial administrators, this type of semi-skilled labour can be recruited in large numbers from the more intelligent workers who have had no previous industrial experience.

There remains the problem of the highly skilled workers. How shall the shortage of these be made up? There are several ways in which this problem may be tackled. First there must be the willing co-operation of the union organizations of the skilled workers. With their co-operation industrial management will be able to organize their working forces so as to employ the maximum of partly-skilled labour under the minimum of fully-skilled supervision. Even under normal industrial employment, great numbers of workers who might otherwise be largely ineffective, can and do become valuable and productive under competent supervision.

In many of the more delicate operations involved in manufacturing small mechanical equipment and instruments, Canadian women can and probably will play an important and valuable part, as indeed they did in the last war. The ranks of the skilled workers may further be augmented by the best of the students training at the technical and vocational schools and by the re-employment of men who have had industrial training but have abandoned it for other employment. No time should be lost in encouraging efforts to make the best use of these sources of skilled helpers.

Research Work

Since the last war, an important contribution to the growth and pro-

gress of this Dominion as a scientific and industrial state has been made by research workers. Fortunately Canada has been farsighted in supporting this fundamental aid to industrial progress. Until war broke out the problems which engaged the National Research Council were naturally more concerned with peacetime problems, but today the activities of a staff, doubled in number, are devoted almost exclusively to war problems.

One recalls with pride the effective aid rendered to Britain by a small group of Canadian specialists during the last war. In those days such research as was carried out in Canada was largely in the realm of pure science. Scientific research specifically directed toward the improvement of industrial processes was hardly recognized. Today, scientific research dealing with industrial production is acknowledged as a contribution of fundamental importance.

It is gratifying that there is the closest co-operation between Government war departments, such as the Department of National Defence and the Department of Munitions and Supply, and the various organizations carrying on research work. Many experienced engineers are officers in one or other of the three fighting services and it is natural that they should seek the aid of the various research bodies in solving the problems that confront them in carrying out their military duties.

Adequate Power Resources Available

I have already referred to the tremendous growth of developed power resources that has taken place in Canada since the last war. Some concern has been expressed as to whether the power available would be sufficient to service our war activities. Speaking for Ontario—and I believe the same may be said for most, if not all, of the other provinces—I have previously expressed the conviction that for the immediate future there was sufficient power available in all districts to enable Ontario's war effort to be speeded up and maintained at this higher level. Since this opinion was expressed war production has increased; war industries have been getting into their stride and greatly increased demands for power have so far been met without undue difficulty.

One must remember, however, that an increased demand for power for war industries is inevitably accompanied by an increased tempo in nearly all activities, and this produces an increased demand for power all along the line, including domestic and commercial demands. Furthermore—differentiating between power and energy—increased demand for power is associated with an even greater growth in the use of energy.

It remains true, therefore, as I have pointed out before, that Canada cannot play the full part that is being assigned to her, and that she is willingly accepting, unless there can be made available large additional quantities of power. One of the chief factors that must be recognized in providing large additional quantities of electrical power derived from water-power developments is that we cannot wait until the demand materializes, we must plan and move well in advance.

Now there has never been a time when future needs for power have been more difficult to estimate. The reasonably possible maximum and minimum demands never seemed so far apart. It is in a veritable maze of uncertainties and indeterminates, therefore, that weighty decisions respecting the provision of new developments have and are being made.

Since we cannot hope to hit the mark squarely we must be guided to some extent by the relative seriousness of the consequences of under- or over-supply. Over-supply, as we well know, is undesirable from a financial viewpoint, but, speaking generally, the electric supply industry is in a strong financial position. Under-supply, as we know equally well, is a different story. It, too, would have an effect, in profit and loss, directly upon industry, but this fact by comparison with other facts, would be relatively insignificant. The real cost of under-supply would, in this wartime, be measured in terms of those things in life that we hold most dear—the avoidable losses of human life and the weakening of our war effort with all the consequences this might entail. The electric supply industry of Canada must, and I believe is, preparing itself to meet the demands that may be made upon it, no matter what they may be.

Ontario Prepares

In Ontario we have been making provisions for the growth that, to the best of our interpretation of the trends, may be anticipated. Even before the war started we had planned, and have since carried out, a general strengthening of our transmission and distribution networks which enables us to transfer power with greater facility from one part of the province to another; we also constructed one additional power development. At the present time we have under construction two others.

We have also been able, in co-operation with the Dominion authorities, to arrange for the use of a greater diversion of water at Niagara by undertaking to make permanent diversions to the Great Lakes of a substantial flow of water from certain rivers in Northern Ontario. As these diversions, known as the Ogoki River and Long Lake diversions, may be of interest to the engineers of Western Canada, perhaps you will permit me to explain briefly the circumstances and physical facts relating to them.

Diversions of Water to Great Lakes

First may I say that the value of these diversions at the present time rests directly upon the co-operation extended by the United States. The friendly co-operation of the United States has resulted in an understanding (confirmed by formal interchange of notes between the Canadian Minister to the United States and the United States Secretary of State) whereby Canada is enabled to utilize immediately, for increasing power output at Niagara for war purposes, an additional flow of water equivalent to that which will be added to the Great Lakes when the diversion works are completed.

The abstraction or diversion of water from a watershed is frequently undertaken for domestic supplies to large cities, sometimes for sanitary purposes for sewage dilution, for irrigation, and frequently, during recent years, for

power development. But because diversions may, or may not, be beneficial, they should not be undertaken without the most thorough investigation. Basically the justification for a diversion or abstraction lies in the ability to secure thereby a greater benefit to a greater number.

These diversions will work no injury to any future industries or settlements which might later be established in the watershed of the Albany river, as there is ample power at other sites in the vicinity of the Ogoki area.

Turning to the province of Quebec, there have been large additions recently made to generating equipment at the Beauharnois power development on the St. Lawrence river near Montreal and at the new La Tuque plant of the St. Maurice Power Corporation, both of which will be immediately absorbed in Quebec's new war industries.

St. Lawrence River Improvement

While considering the power resources of Ontario and Quebec it is appropriate just to refer to the St. Lawrence river. The improvement of this great river for navigation and for power development is a subject that is again prominent in the public thought of the people of Eastern Canada. It is undoubtedly an enterprise that will profoundly influence the growth and progress, not only of Ontario and Quebec but of the whole of Canada. As a project it is now linked up with the joint steps being taken by the United States and Canada for the defence of the Americas. Time will not permit any discussion of the proposed further development of this great waterway so bound up with Canadian and United States history. It is evident, however, that changing world conditions must profoundly modify many of the views previously held respecting this great undertaking.

Regulation by Dominion Power Controller

While we do not anticipate that the necessity will arise in acute form as it did in the last war, nevertheless there are certain economies in consumption that can be effected by the imposition of restrictions on the less essential uses of electricity. Great care, however, must be exercised in determining when and how to impose such restrictions. It is quite possible to secure a saving in electricity at the cost of imposing other burdens which would diminish rather than increase our total war effort. These matters are, of course, receiving the careful attention of the Dominion Power Controller, in co-operation with the various provincial authorities.

One ruling by the Dominion Power Controller has already effected a substantial saving in power demand—namely the extension of daylight saving time in Ontario and Quebec in those communities which adopted it during the summer. This regulation has unfortunately resulted in some confusion in the mind of the general public.

Since the introduction of daylight saving time in Ontario and Quebec there have been various suggestions made in the press that electric power could be conserved by cutting off street and highway lighting, and electric signs, and some people have gone to the length of trying to conserve electricity in their homes. Such efforts,

while being commendable because they are sincere, are not very helpful. You do not, for instance, reduce generating station peak loads by switching off night lighting, or by darkening homes and streets, unless you happen to switch off lights when your generating stations are operating at their maximum capacity—which is usually late in the afternoon when all factories are in full production.

When you are operating with stored water, or with coal, you would of course save energy. But I would recommend that everybody should continue to use electricity as fully as needed until they receive advice from the Dominion Power Controller, or their local electric utility, otherwise they may interfere with their own war effort.

Engineers will understand that the effect of introducing a staggered form of Daylight Saving Time (as has been done in Ontario and Quebec) creates a better diversity in the time of peak demands from various classes of consumers.

Conclusion

My brief review of Canada's war effort has, I hope, indicated to some extent the important part that must inevitably be played by Canadian engineers.

There is, I believe, one consideration that may be an encouraging thought to us all. In the last war it was, I think, generally conceded that in scientific and technical matters, at least as applied to military efforts, Germany had stolen a march on Britain. But today, notwithstanding the temporary superiority enjoyed by Germany in numbers and masses of military weapons and supplies, it may be stated with some assurance that in scientific and technical matters the British Empire is superior to Germany. This is to be expected because the highest achievement in these things is in part a matter of the spirit, and can only be attained where the utmost freedom of thought and action are permitted. While dictatorships may have some advantages over democracies in the regimentation of a nation for controlling its political and economical life, the same control cannot successfully be applied to its scientific development.

In addition to its natural resources and its up-to-date equipment for their utilization, Canada enjoys for the time being a freedom from direct enemy action against her territory. This is both an advantage and a danger. It leaves us free to devote, without let or hindrance, our energies to our assigned task of training personnel for the great air armada in the making, and to develop our raw materials and manufacture and assemble them for shipment. The danger lies in the possibility that we may become complacent and fail to mobilize every ounce of our strength.

Relatively speaking, Canada has as much to lose, should the Empire fail to achieve victory, as even Britain herself. Just before the war Germany had many accredited agents travelling through Canada making an inventory of our assets. Asked what they were agents replied, "In your natural resources". Canada, therefore, has a very definite and important part in the struggle. We must develop and use our natural resources to the utmost to

prevent the enemy from taking them from us.

Great things are expected of us. It is our part to be an efficient machine shop, a storehouse on which our Empire may call and, not least, a source of inspiration and help to the hard-pressed people of Britain.

As Canadians we may take pride in the fact that those to whom the call has come have been found both anxious and capable to render effective service. We cannot all apply our specialized knowledge and experience, as Captain Robert Davies is doing, to the removal of time bombs from cathedrals. Neither will many of us be called upon to make the outstanding contribution to Canada's war effort that the engineering and military qualifications of Major General McNaughton, now Lieutenant-General, enable him to make. But in less prominent capacities we can each employ our native talents, our experience and whatever specialized knowledge we may possess to the solution of the problems with which we have to deal—to the end that, by the efficient mobilization of the great resources of this Dominion, a continuous stream of munitions and supplies of all kinds may be directed through unimpeded channels to their appointed destination.

The Second Mile

By Dr. William E. Wickenden, President, Case School of Applied Science, Cleveland, Ohio, U.S.A.

"WHOSOEVER shall compel thee to go one mile—go with him twain." I am not sure that I should dare to choose this counsel of perfection from the Sermon on the Mount as a text for a talk to engineers south of the border, such is the present state of our biblical illiteracy. The professor of a past generation who withered a classroom disturbance at Yale by urbanely remarking "Young gentlemen, I beg you to restrain yourselves until I cast one more pearl," would be met to-day by uncomprehending stares. Some one has said that the trouble with us in the States is that we have lost three pasts; first we lost the classical past, next we lost the biblical past, and now we are losing the historical past. In Canada where, I believe, you are much more deeply rooted in piety and sound learning, you will catch the meaning of my text. Every calling has its mile of compulsion, its daily round of tasks and duties, its standard of honest craftsmanship, its code of man-to-man relations, which one must cover if he is to survive. Beyond that lies the mile of voluntary effort, where men strive for excellence, give unrequited service to the common good, and seek to invest their work with a wide and enduring significance. It is only in this second mile that a calling may attain to the dignity and the distinction of a profession.

A preacher who was once reproached for straying rather widely from his text replied "A text is like a gate, it

From Address delivered at the Annual Banquet of The Engineering Institute of Canada, Hamilton, Ont., February 7th, 1941.

has two uses; you can either swing on it, or you can open it and pass through." Let us pass on through. There is a school of thought that seems to hold that all of the problems of the engineering profession may be solved by giving it a legal status. If only we compel all who would bear the name of *engineer* to go the mile of examination and licensure, we shall have protection, prestige and emoluments to our hearts' desire. They forget, perhaps, that there are many useful callings which have traversed this mile without finding the higher professional dignities at its end. We license embalmers, chiropodists, barbers and cosmetologists, but we do it for the protection of the public, and not to erect them into castes of special dignity and privilege.

There is an illusion abroad that any calling may win recognition as a profession by the mere willing it so and by serving notice to that effect on the rest of the world. It helps a lot, too, if you can invent an esoteric-sounding name derived from the Greek. One reads, for example, of a group of barbers who elect to be known as "chirotonsors" in order to raise the prestige of their "profession." The truth seems to be that as soon as any word acquires a eulogistic character, we promptly proceed to destroy it by indiscriminate usage. When one scientist observed what the advertising fraternity has done to the word *research*, he remarked dryly that we now use that word to mean so many things we shall soon have to invent another word to mean *research*. The ambition to dignify honourable work is laudable, but there is much seizing after the form and letting the substance escape which would be ludicrous, if it were not pathetic.

A prominent English churchman once remarked facetiously that there were three sorts of Anglicans—the low and lazy, the broad and hazy, and the high and crazy. It seems to be much the same among engineers in our thinking about our profession. We have a low church party which holds that status and titles are of little consequence; so long as the public allows us to claim them not much else matters if the engineer does an honest day's work. The broad church party is all for inclusiveness; if business men and industrialists wish to call themselves engineers, let us take them in and do them good, not forgetting the more expensive grades of membership. The high church party is all out for exclusive definitions and a strictly regulated legal status; in their eyes, what makes a man a "professional" engineer is not his learning, his skill, his ideals, his public leadership—it is his license certificate.

In view of these divided counsels, it may not be amiss to consider briefly what a profession is, how it came to be, why it exists, how its status and privileges are maintained and what obligations it entails; and finally to discuss a few of our current issues in the light of these backgrounds.

Of professions there are many kinds; open professions like music, to which any man may aspire within the bounds of his talents, and closed professions like medicine which may be entered only through a legally prescribed process; individual professions like painting and group professions like law,

whose members constitute "the bar," a special class in society; private professions like authorship and public professions like journalism; artistic professions like sculpture and technical professions like surgery; ameliorative professions like the ministry and social work and professions which achieve their ends by systematic destruction like the army and navy. Despite all these differences of pattern, there are characteristic threads which run like a common warp beneath the varying woof of every type of professional life and endeavour.

If one seeks definitions from various authorities, he finds three characteristic viewpoints. One authority will hold that it is all an *attitude of mind*, that any man in any honourable calling can make his work professional through an altruistic motive. A second may hold that what matters is a certain *kind of work*, the individual practice of some science or art on an elevated intellectual plane which has come to be regarded conventionally as professional. A third may say that it is a special *order in society*, a group of persons set apart and specially charged with a distinctive social function involving a confidential relation between an agent and a client, as the bar, the bench and the clergy. Another source of confusion arises from the fact that some define a profession solely in terms of ideals professed, others solely in terms of practices observed, and still others in terms of police powers exercised. All authorities recognize that some of the distinguishing attributes of a profession pertain to individuals, while others pertain to groups, but there is considerable variation in the emphasis given. Let us glance briefly at these two sorts of distinguishing attributes.

What marks off the life of an individual as professional? First, I think we may say that it is a *type of activity* which is marked by high individual responsibility and which deals with problems on a distinctly intellectual plane. Second, we may say that it is a *motive of service*, as distinct from profit. Third, is the *motive of self-expression*, which implies a joy and pride in one's work and a self-imposed standard of workmanship—one's best. And fourth, is a *conscious recognition of social duty* to be accomplished, among other means, by guarding the standards and ideals of one's profession and advancing it in public understanding and esteem, by sharing advances in professional knowledge and by rendering gratuitous public service, in addition to that for ordinary compensation, as a return to society for special advantages of education and status.

Next, what are the attributes of a group of persons which mark off their corporate life as professional in character? I think we may place first *a body of knowledge* (science) *and of art* (skill), held as a common possession and to be extended by united effort. Next we may place *an educational process* of distinctive aims and standards, in ordering which the professional group has a recognized responsibility. Third in order is a *standard of qualification*, based on character, training and competency, for admission to the professional group. Next follows a *standard of conduct* based on courtesy, honour and ethics, to guide the practitioner in his relations with

clients, colleagues and the public. Fifth, I should place a more or less formal *recognition of status* by one's colleagues or by the state, as a basis of good standing. And finally *an organization* of the professional group based on common interest and social duty, rather than economic monopoly.

The traditional professions of law, medicine, and divinity had a common fountain head in the priestcraft of antiquity. What is professional in engineering and in certain other modern callings can be traced back only so far as the mediaeval merchant and craft guilds. These arose in the period when feudal society was breaking down and the beginnings of the modern commercial and industrial era were appearing. In this period of disintegration and remaking of the social order, before cities had grown strong and central governments powerful, police powers had not been largely developed or protective services created by the state. Men who wished to engage in far-flung commerce or in trade on any extensive scale found it necessary to organize for mutual protection, and this in turn led to monopolistic control. In the various crafts it was the guilds which regulated by ordinance the hours of labour, the observance of holidays, the length and character of apprenticeship and the quality of workmanship; and it was the guild which tested the progress of novices, apprentices and journeymen and finally admitted them to the ranks of the masters. When the cities and the states waxed powerful, they usually confirmed the monopolies which the guilds had gathered to themselves and even incorporated them into the structure of the municipality, as in the City and Guilds of London. The church too lent its blessing, since the religious philosophy of the middle ages regarded society as a commonwealth divided into divinely ordained functions, and not as a mere aggregation of individuals—an idea which recent Papal encyclicals have sought to reanimate under the name of a corporative society. In the spirit of the times, the guilds required members to contribute periodically to a common fund for the relief of distress, to participate in certain religious observances and to honour certain festivities and pageants.

Many of these features are perpetuated in the modern professional body. The public grants it more or less tangible monopolies and self-governing privileges, in consideration of which it engages to admit to its ranks only men who have proved their competency, to scrutinize the quality of their work, to insist on the observance of ethical relations, and to protect the public against extortion and bungling. The occasion which calls for professional service is often a human emergency in which the legal doctrine of *caveat emptor*—let the buyer beware—breaks down. When a baby is about to be born or an appendix must be removed, you want some guarantee that the job is in competent hands. The layman often finds professional knowledge and skill a little too esoteric for his judgment. If you have a problem of mental hygiene in your family you want some guarantee that you are dealing with a qualified psychiatrist and not with a quack. The public wisely puts the burden of guaranteeing at least minimum standards of competency on the profession itself. It may implement

this obligation through public examinations and licensure, or it may entrust it to a system of certification within the profession itself, but in the end it comes down to the same thing—a profession must guarantee to the public the competency of its practitioners. In return, the public protects the profession from the incompetent judgment of the layman by a privileged status before the law.

Through all professional relations there runs a three-fold thread of accountability—to clients, to colleagues, and to the public. Is business a profession or can it be made so? We sometimes hear it referred to as the oldest of trades and the newest of professions. It seems clear that business is moving away from the dog-eat-dog area to one nearer the fringe of professional life. This occurs when the direct management passes from the hands of proprietors to a distinct administrative caste with little immediate stake in the profits of trade. Business may still be far from a true profession, but management is well within the pale. Business has lived traditionally from balance-sheet to balance-sheet; the time-span of its thinking has often been about three months; the profit-and-loss statement has been its only yard-stick. Professional managers, if assured of reasonable security of tenure, are better able to think and plan in terms of long-range prosperity and to act as responsible middlemen between investors, workers, customers and the public. At one time I worked for the Bell Telephone System, of which no individual owns as much as one per cent. It is the best example of manager-operated, as distinct from owner-operated, business that I know of and the one that comes nearest to fulfilling professional standards.

The ethical obligations of a profession are usually embodied in codes and enforced by police powers. The physician and lawyer are bound by explicit obligations and woe betide the man who oversteps them. As engineers, our codes are more intangible, as our duties are less definable. In any case, the obligations of a profession are so largely matters of attitude that codes alone do not suffice to sustain them. Equal importance attaches to the state of mind known as professional spirit which results from associating together men of superior type and from their common adherence to an ideal which puts service above gain, excellence above quantity, self-expression above pecuniary incentives and loyalty above individual advantage. No professional man can evade the duty to contribute to the advancement of his group. His skill he rightly holds as a personal possession, and when he imparts it to another he rightly expects a due reward in money or service. His knowledge, however, is to be regarded as part of a common fund built up over the generations, an inheritance which he freely shares and to which he is obligated to add; hence the duty to publish the fruits of research and to share the advances in professional practice. If the individual lacks the ability to make such contributions personally, the least he can do to pay his debt is to join with others in creating common agencies to increase, disseminate and preserve professional knowledge and to contribute regularly to their support.

The climax of man's effort to sub-

due nature, shift labour from muscles to machines, to make material abundance available for all, and to abolish poverty and disease, may well fall in the next fifty years. After that human interest may shift from work to leisure, from industry to art. Meanwhile engineers will multiply, research will expand, and industry will grow more scientific. Engineers will find their way into every field where science needs to be practically applied, cost counted, returns predicted and work organized systematically. They will be called upon to share the control of disease with physicians, the control of finance with bankers, the bearing of risks with underwriters, the organizing of distribution with merchants and purchasing agents, the supplying of food with packers and purveyors, the raising of food with farmers and the operation of the home with housewives. In few of these new fields, if any, will engineers be self-sufficient; to be useful they must be team-workers; and they must be prepared to deal with "men and their ways," no less than "things and their forces."

The engineering profession will exercise a far greater influence in civic and national affairs. It will probably never be able to define its boundaries precisely, nor become exclusively a legal caste, nor fix a uniform code of educational qualifications. Its leaders will receive higher rewards and wider acclaim. The rank and file will probably multiply more rapidly than the elite, and rise in the economic scale to only a moderate degree.—*The Engineering Journal.*

Large Electrical Systems

DATA on the output and loads of the largest generating and distributing systems on the North American continent, for the years 1937 to 1940, are given in the May 3, 1941, edition of *Electrical World*. The report includes all public utility, lighting, power and electric railway systems in the United States, Canada and Mexico having output in excess of 100,000,000 kw-hr. during 1940. There are 186 systems listed of which 155 are public utilities in the United States, 17 in Canada and one in Mexico, and 13 electric railways in the United States.

The systems are listed under each country or classification in the order of kilowatt-hours reported for 1940. Disregarding the grouping used in the report, The Hydro-Electric Power Commission is reported as having the greatest output, viz. 9,804,992,000 kw-hr. Second in that order is the Niagara Hudson System with 8,783,159,000 kw-hr. Following these are the Commonwealth Edison Company and subsidiaries with 8,120,844,000, the Consolidated Edison Company of New York, Inc. with 7,541,519,000 and the Pacific Gas and Electric Company with 6,058,274,000 kw-hr. Sixth in this order is the Shawinigan Water and Power Company and subsidiaries with 5,899,605,000 kw-hr. Taking the output year by year the amounts reported for The Hydro-Electric Power Commission of Ontario are,—

1937 — 7,842,343,000 kw-hr.
1938 — 7,670,559,000 "
1939 — 8,673,283,000 "
1940 — 9,804,992,000 "

In 1937 the Commission was in second place, the Niagara Hudson System being first, with 8,056,607,000 kw-hr. The slight falling off indicated in 1938 was more pronounced with the other systems in that year with the result that the Commission advanced to first place which it still holds.

Taken in the order of system peak loads, The Hydro-Electric Power Commission is in second place, having 1,621,772 kw. Consolidated Edison Company of New York, Inc. is first with 1,704,000 kw. Consolidated Edison Company and subsidiaries with 1,612,000 kw. is third and the Niagara Hudson System with 1,491,400 kw., fourth. These amounts include purchased energy. On the basis of the peak loads generated, the Commission is in fourth place with 1,065,224 kw. being exceeded by the Consolidated Edison Company of New York, Inc. with 1,702,000 kw., the Commonwealth Edison Company and subsidiaries with 1,601,000 kw. and the Niagara Hudson System with 1,328,700 kw.

Under the column headed generator nameplate rating, The Hydro-Electric Power Commission is shown as fourth largest with 1,377,690 kw., the largest being the Consolidated Edison Company of New York, Inc. with 2,527,300 kw., the next the Commonwealth Edison Company and subsidiaries with 2,099,000 kw., and the third the Niagara Hudson System having 1,656,664 kw.

As a matter of historical interest the report refers back to statistics that had been given for the year 1915. That report gave data on 37 companies, 36 of which were in the United States and accounted for 13,000,000,000 kw-hr. out of a total for the country of 18,400,000,000 kw-hr. From this and data given in the foregoing the output of the Commission in 1940 was over 53 per cent of the total output in the United States in 1915. The peaks of the entire United States in 1915 aggregated 2,713,600 kw. or 67 per cent greater than the Commission's peak for 1940.

New Concrete Specifications

ONE of the most important structural materials used in construction is concrete and the Commission uses many thousands of cubic yards annually. Through its Research Committee, it has for years been a leader in Canada and the United States in the field of concreting, especially in the control of the quality of concrete in its structures. Some time ago a revision was made of its specification for small jobs, designated as "Instructions for Concrete on Jobs of Less Than 500 Cubic Yards"*. This is now supplemented by a general specification designed for the control of concrete on the Commission's larger hydraulic structures although it is applicable to concrete work generally. It is reproduced here with the thought that it might be useful to many of the readers of *The Bulletin*.

In general, the specification follows conventional lines and is similar to that of the Canadian Engineering Standards Association, and others. It embodies many of the recommendations of the recent Joint Committee Report on Concrete and Reinforced Concrete and the modern practices followed on recent hydraulic projects in the U.S. But in spite of this general agreement with current practice, the specification is primarily designed for the Commission's own work with special attention being given to the problems that are peculiar to the operations of the Commission.

As an example, the storage of materials is covered in considerable detail. Lack of the usual transportation facilities in Northern Ontario frequently requires that construction materials be hauled over roads only usable in the winter and under these conditions, cement, a perishable material, may have to be stored for months before use. Moisture-proof protection is necessary during both the period of shipment and the time of storage and special containers are required. On the Ogoki Diversion special moisture-resistant sacks with asphalt-impregnated liners are being used where covered storage is to be provided, and metal drums of four-sack capacity where the cement is to be stored in the open. In connection with the storage of aggregates, special precautions are required to avoid segregation and contamination in the stockpiles and consideration is given to proper drainage.

The application of the specification to hydraulic work is shown by the requirement for a higher percentage of fines in sand than it is usual to require when structural concrete is being manufactured. Experience has shown that sands deficient in fines do not produce as durable and watertight concrete as those of better grading. As a result the minimum percentage of sand finer than the number 50 sieve is set at 12 per cent, a figure that is being approached in the latest U.S. specifications for this type of work. Another feature of the control exercised over grading is to guard against an excessive amount of any one size by limiting the percentage between two successive sieves.

*Published in *The Bulletin*, April 1939.

The specification includes sodium sulphate tests for soundness of coarse aggregate. This test is not generally considered by experts an absolute criterion for the soundness of aggregates but rather as a warning that aggregates that will not meet it should be viewed with suspicion until proved to be suitable. However, in the territories in which the Commission operates it has been found that it is easily possible to obtain economically, aggregates that meet this test and it has been made a part of the specification to provide a simple and definite means of eliminating questionable material.

The use of emulsified asphalt of the proper grade for providing a watertight seal at joints has been standard practice for a considerable time and its continued use is warranted by the generally satisfactory results that have been experienced. In use it is applied to a concrete surface immediately after stripping the forms and concrete should be placed against it after a surface film has formed but before the asphalt has completely hardened. It is to be noted that a V-joint is now required at exposed corners to prevent pinching and spalling of the edges by expansion.

For exposed concrete a minimum strength of 3,000 lb. per sq. in. is required since it has been found that this is the lowest strength that is in keeping with the desired degree of durability. Accuracy of batch proportions on all jobs over 1,200 cubic yards is obtained by weighing all ingredients. On smaller jobs where similar accuracy is not provided additional cement is used to maintain an adequate factor of safety. In all events the specification stresses the need for the greatest possible accuracy in keeping with the importance of a project.

Since watertightness is of prime importance in dam and powerhouse structures, emphasis is given to the prevention of leakage at foundations, and horizontal construction joints are avoided wherever possible. Proper preparation of foundation surfaces is required before placing is started and further aid in providing a good bond is obtained by brooming a layer of grout into the surface when a lift is being started. It is forbidden to place concrete in a flooded excavation except by tremie. The Commission's general policy, aimed at the elimination of construction joints, is to place the concrete in monoliths, that is, to pour each construction block in one continuous operation, a method which contrasts with the general U.S. method of shallow lifts. Continuous placing is considered no more costly than intermittent placing and has the decided advantage of eliminating construction joints which are a source of frequent trouble.

The specification provides for the use of ready-mixed in place of the usual plant-mixed concrete when it can be used to advantage. It also deals with the manufacture of mortar for "dry pack" grouting. This mortar is used in setting machinery and on other jobs where minimum shrinkage is desirable.

In cold weather operations the water, and aggregates if the weather is cold enough, is to be heated to a degree which depends upon the severity of the temperature. Excessively high placing temperatures that may increase the cracking tendency are forbidden. Protection from freezing is required

during the curing period, with special attention being paid to the curing of surfaces exposed to the weather. It is customary to regulate the protection to the expected severity of the weather and to treat different parts of a structure in accordance with their functions. For instance corners and edges, the parts most subject to freezing and to disintegration in service, require the heaviest insulation or the most careful provisions for supplying heat if construction is carried on within an enclosure. Surfaces of spillways and the edges of piers are given the most careful protection and for a much longer time than are those surfaces that are to be later covered or otherwise protected when the structure has been completed. Sloping and horizontal surfaces are protected more carefully and are cured more thoroughly than are vertical surfaces whose exposure is not so great. In other words, an attempt is always made to strike a balance between protection and exposure.

In handling and placing concrete the most usual practice of the Commission is to pump the material, but other methods may be used provided that they are capable of satisfactory results. All practices that may cause segregation are to be avoided, one of the restrictions being that the material shall be deposited in horizontal layers. Collection of excess water at the faces is avoided by placing concrete at the edges slightly in advance of depositing in the interior of the blocks. Vibrators are now considered a necessity on all jobs of importance, especially where stiffer mixes or difficult placing conditions are involved.

Curing of the concrete, often an afterthought with construction men, is recognized as a necessity in this specification. The advantages of proper curing are often not appreciated, but its value may be indicated by the fact that a ten-day moist curing period is often capable of increasing compressive strength by as much as 50 or 70 per cent of that of uncured concrete of the same composition.

Provision is made for inspection and testing by establishing adequate field laboratories on all jobs of importance. Each section of a structure must be represented by test specimens which provide a tangible record of the concrete placed, a practice which has an important effect on the quality.

For surfaces exposed to the weather it is customary to use a wood float rather than a steel trowel for finishing since experience has shown this method to provide a more durable surface. Where appearance is of prime importance rubbing with a carborundum brick may be required.

The Commission has long been a pioneer in certain phases of concrete practice, the justification for which is provided by the success achieved and by the tendency of other organizations to adopt its methods. In keeping with this position is such a specification as the one under discussion, since it is one whose terms are sufficiently comprehensive that they can be applied to all structures of importance, whether constructed under contract or by Commission forces. In thus presenting a definite statement of policy, it is confidently expected that the specification will aid considerably in maintaining

desired uniformity and quality in the Commission's structures.

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Space does not permit our publishing the whole specification in one issue. It is therefore divided into two parts, this number including the preparation of the concrete and that to follow in the next number, the placing and curing. —Editor.

The Hydro-Electric Power Commission of Ontario

SPECIFICATIONS FOR CONCRETE

No. 410527

1. Authority

The word "Engineer" shall mean the Chief Engineer of the Hydro-Electric Power Commission of Ontario, acting either directly or through the architect, or through his properly authorized representatives and inspectors.

Wherever it is stated that material or work is to be "approved", "similar", "satisfactory", "proper", "equal", or "the equivalent", it shall mean that the materials or work must be satisfactory to the Engineer before it will be accepted by the Commission.

Unless otherwise specified herein, all tests on cencrete, Portland cement, and aggregate, called for by this Specification, shall be carried out by the Engineer at the Commission's expense, in accordance with the methods specified in Standard Specification No. A23-1929 for Concrete and Reinforced Concrete of the Canadian Engineering Standards Association, hereinafter referred to as the "C.E.S.A. Specification". Copies of Engineer's test reports will be supplied to Contractor for his information.

2. Portland Cement

(a) *Quality*

Cements shall conform to the Standard Specification No. A5-1940 on Portland Cement, and No. A57-1940 on High-Early-Strength Portland Cement of the Canadian Engineering Standards Association.

(b) *Sampling and Testing*

The contractor shall notify the Engineer immediately of all purchases of cement for the work, and the Engineer shall arrange for the sampling and testing of each. The cost of sampling and testing will be paid for by the Commission.

(c) *Acceptance*

No shipment of cement shall be used on any part of the work until it has been approved by the Engineer. Cement will not be accepted for use on the results of the soundness, fineness and setting tests alone, but tensile strength tests shall be required.

(d) *Storage*

Cement shall be stored in a weather-tight building. The floor of the building shall be raised above the ground and covered with a waterproof paper to ensure dryness. The cement shall be piled as compactly as possible and stored in such a manner as to permit easy access for proper inspection and identification of each shipment.

Cement that will be in storage for

three months or longer shall be shipped in waterproof sacks similar to Type 2706 supplied by the Bates Bag Company.

(e) *Damaged Cement*

Cement damaged by weather shall not be used and all damaged cement from whatever cause shall be removed immediately from the work.

3. Aggregate, General

(a) *Quality*

All concrete aggregate shall consist of natural sands and gravels, crushed rock, or other inert materials having clean, uncoated grains of strong and durable materials.

All aggregate shall be free from alkali, organic matter, or other deleterious substances, and shall not contain soft, friable, thin, flaky, elongated, or laminated particles totalling more than 3 per cent or contain shale in excess of 1½ per cent, or silt and crusher dust finer than the No. 100 sieve in excess of 1 per cent.

(b) *Sieve Analyses*

The sieves and method of making sieve analysis shall conform to the "Methods for Sieve Analysis of Aggregates for Concrete" given in Appendix VII of the C.E.S.A. Specification.

(c) *Pit-Run Aggregates*

Pit-run aggregates or plums shall not be used.

(d) *Samples*

The Contractor shall notify the Engineer of the source of each kind of aggregate that he proposes to use, not less than three weeks in advance of the concreting operations, and shall furnish the Engineer with samples of each. All samples shall be delivered in suitable containers plainly labelled as to when and where taken, and each sample shall contain at least 2 cubic feet of material.

(e) *Storage*

Aggregates shall be so stored on platforms or otherwise as to avoid the inclusion of foreign materials. Materials shall be so stored that one aggregate will not be mixed with the other when reclaiming. Foreign or mixed material will not be accepted. Before using, ice and lumps of frozen material shall be removed.

The formation of conical stock piles of coarse aggregate by the deposition of materials in one place will not be permitted. Stock piles of coarse aggregates shall be built up in successive horizontal layers, of which each layer shall not be more than three feet in thickness. Each layer shall be completely in place before the next is started. Should the aggregate become segregated, it shall be remixed so as to conform to the grading requirements of the specifications. All aggregates produced or manipulated by hydraulic methods and all washed aggregates shall be handled in such a manner as to permit drainage for at least twelve (12) hours before use.

Before concreting of any section is undertaken, there shall be sufficient aggregates on the job to complete that section.

(f) *Permissible Variations*

Aggregate that does not conform to the requirements for quality, grading, mortar strength or organic matter may be used only when approved by the Engineer and then in such proportions as he may require.

4. FINE AGGREGATE

(a) *Grading*

Fine aggregate shall be graded fine to coarse within the following limits:

Per cent Passing (by weight)

No. 4 sieve—Not less than 95 per cent.

" 50 " —Not more than 30, and not less than 12 per cent.

" 100 " —Not more than 5 per cent.

Weight removed by decantation—Not more than 3 per cent.

Not more than 75 per cent by weight of the fine aggregate shall lie between sieves No. 8 and 30, nor between sieves No. 16 and 50.

Normal moisture in natural sand varies from 3½ to 5 per cent and any moisture in excess of 5 per cent by weight will not be paid for. When transportation on the sand is paid for by the Commission the charges on this excess water will be deducted from the cost of the sand.

(b) *Impurities*

Fine aggregate, when tested in accordance with the Method of Test for Organic Impurities in Sand for Concrete, Appendix X, of the C.E.S.A. Specification, shall show a colour not darker than the standard colour.

(c) *Mortar Strength*

Fine aggregates shall be of such a quality that mortar specimens consisting, by weight, of one part of Portland cement and three parts of fine aggregate, will, when tested at the ages of 7 and 28 days, have a compressive strength of at least 90 per cent of that developed by similar specimens made from the same cement and using Niagara bar sand of the same grading. The mortar specimens shall be cylinders 2 inches in diameter and 4 inches in height. The tests shall be conducted for water-cement ratios of both 0.60 and 0.70, by weight.

(d) *Decantation Test*

The decantation test shall be made in accordance with the "Method of Decantation Test for Sand and Other Fine Aggregates" given in Appendix VIII of the C.E.S.A. Specification.

5. COARSE AGGREGATE

(a) *Grading*

Coarse aggregate, unless otherwise specified, shall range in size from fine to coarse within the following limits:

Passing	Per cent by Weight
2 in. sieve	—Not less than 95
1 in. "	—Between 40 and 75
No. 4 sieve	—Not more than 10
No. 8 "	—Not more than 5

(b) *Coarse Aggregate—Maximum Size*

Unless otherwise specified the rated maximum size of aggregate used shall be two inches.

Where other than 2-inch maximum sizes are specified, the rated sizes of the aggregate shall fulfil the requirements of the C.E.S.A. Specifications.

(c) *Soundness*

Coarse aggregate shall not be used except on the Approval of the Engineer, if, when subjected to the following test for soundness, it shows signs of cracking or disintegration.

Twenty pieces of coarse aggregate between ½ inch and 1½ inches in diameter, of a total weight of approximately 2,000 grams, shall be immersed in a saturated solution of sodium sulphate (Na_2SO_4), shall be maintained for twenty hours at a temperature of about 70 deg. cent., and shall then be

immediately removed to a drying oven, and kept there for four hours at a temperature of about 212 deg. fahr. This treatment shall be repeated five times.

6. Water

Water for concrete shall be clean, and free from injurious amounts of oil, alkali, organic matter, or other deleterious substance. Unless the water to be used is of a known satisfactory quality, a sample shall be submitted to the Engineer for approval prior to its use.

7. Admixtures

No materials other than Portland Cement, aggregate, water, and reinforcement shall be included in any concrete unless specifically authorized by the Engineer.

8. Emulsified Asphalt

Where emulsified asphalt is used as an expansion joint filler or waterproofing material, the asphalt shall be of a "clay" type and subject to the approval of the Laboratory. It shall be applied as soon as possible to the concrete surface after stripping so that it may lose some of its moisture and solidify, sufficiently to prevent its removal by the water or concrete coming in contact with it. It is not desirable that the asphalt become definitely hard before placing concrete against it. If it has become hard it shall be recoated or "served" with a fresh coat of asphalt and the latter allowed to lose moisture until it becomes tacky before placing fresh concrete against it. The condition can be determined by touching the asphalt with the finger and observing if a surface skin has formed and will not be moved under pressure of the concrete.

Emulsified asphalt shall not be used if it has been frozen and shall not be applied to a surface having a temperature lower than 35 deg. fahr. nor allowed to freeze after application. It shall be at all times during transportation, storage and use maintained at a temperature above 35 deg. fahr. The container being of metal, the asphalt in contact with it will be subject to freezing unless the container is kept in a temperature above freezing point.

9. Quality of Concrete

(NOTE: Clauses (a) to (d) inclusive of Section 9 to be used where the contract is performed by a contractor.)

(a) *Strength*

Concrete, unless otherwise specified, shall have a minimum compressive strength at 28 days of 3,000 lb. per sq. in.

(b) *Quantity Limitations*

A. The cement and water content shall comply with the requirements given in the following table:

Specified Compressive Strength Lb. per Sq. In.	Minimum Cement Sacks per Cu. Yd. of Concrete	Maximum Water Content Imperial Gallons per 87½-lb. Sack of Cement
2000	5	6
2500	5½	5¼
3000	6	4¾

B. The quantity of fine aggregate used shall not be less than 40 per cent or more than 50 per cent by dry weight of the total aggregate.

(c) *Slump*

Unless otherwise directed by the Engineer, concrete shall have a slump not greater than four inches.

(d) *Minimum Cement*

Experience of the Commission in similar work has shown that concrete of the required quality can be made with the minimum quantity of cement specified above where the aggregates and methods used comply fully with these specifications, but the Commission does not guarantee that more than this quantity may not be required and will not be responsible for the cost of any additional cement over and above this minimum quantity, that has to be used to produce concrete of the quality specified.

If desired, the Commission will co-operate with the contractor in every reasonable way in determining by test from samples of the cement and aggregates to be used, the proportions that will meet the specifications.

The Commission shall not be required to compensate the contractor in the event of the concrete strength being higher than specified.

(NOTE: Clause (a-1) of Section 9 to be used when the Commission does its own construction.)

(a-1) *Strength*

The concrete, unless otherwise specified, shall have a minimum compressive strength of 3,000 lb. per sq. in. at the age of 28 days and the proportions shall be determined by the laboratory.

10. MEASUREMENT OF MATERIALS

(a) *General*

When the volume of concrete to be placed in any work exceeds 1,200 cu. yd. all aggregates shall be measured by weight. Permission may be given by the Engineer, in writing only, for volume measurement where the total quantity of the work does not exceed 1,200 cu. yd. of concrete. An additional ½ sack of cement per cubic yard of concrete shall be added to the amount specified where volume measurements are used for aggregate.

(b) *Cement*

Cement shall be measured by weight or by sack. One sack of cement weighing 87½ lb. gross shall be considered to contain one cubic foot. Where weighed, the cement shall be batched on a scale separate from those used for the other materials. When sack measurement is employed no fractions of a sack other than one-half shall be used.

(c) *Aggregate*

Batch measurements shall be corrected to take into account the surface moisture contained in the aggregates.

Where aggregates are measured by volume, they shall be measured loose as placed in the measuring device. The equipment used shall be quickly adjustable and shall be arranged to hold, when full and struck off, the specified quantity for a batch. The fine aggregate hopper shall permit a change in volume of at least 20 per cent, and the coarse aggregate hopper a change of at least 15 per cent. Struck boxes, buggies, and wheelbarrows may be used by permission of the Engineer.

(d) *Water*

Water shall be measured by weight or volume in one batch or be metered. The device for the measurement of the water shall be readily ajustable and under all operating conditions shall measure accurately to within one per cent.

(e) *Tolerances*

Weighing hoppers and scales shall conform to specifications and tolerances

set forth in Bulletin No. 15 of the American Road Builders Association, dated 1931, copies of which may be had on application.

Hoppers in which aggregates are measured by volume shall be so built that a variation of ½ inch in striking off the hopper shall not cause an error in measurement of more than one per cent.

11. Preparation and Inspection of Forms

Immediately before depositing concrete, all forms shall be carefully inspected to ensure that they are properly placed, sufficiently rigid and tight, and thoroughly clean; all debris, sawdust, frozen matter, etc., shall be removed from the space to be occupied by the concrete; the forms shall be thoroughly wetted (except in freezing weather) or oiled with non-staining mineral oil (except where plaster is to be applied directly on concrete) such oiling being done before reinforcing is placed.

Water shall be removed from excavations before concrete is deposited. Any flow of water into the excavation shall be diverted through proper side drains to a sump or be removed by other approved methods that will avoid washing the freshly deposited concrete. Vent pipes and drains shall be filled by grouting or otherwise, after the concrete has thoroughly hardened, unless otherwise required in writing by the Engineer.

12. Preparation of Set Concrete or Rock

Before depositing new concrete on or against concrete that has set, the forms shall be re-tightened, the surface of the set concrete shall be roughened, as required by the Engineer, thoroughly cleaned of foreign matter and laitance, and saturated with water in advance of concreting. Where the concrete is placed on rock or other hardened concrete, dry cement or cement paste shall be broomed into the surface for bonding.

New concrete placed in contact with rock, hardened or partially hardened concrete, shall contain an excess of mortar to ensure bond. This shall be obtained by first placing concrete of the quality specified for that work from which the coarse aggregate has been omitted. The quantity of this concrete and its method of distribution in the forms shall be determined by the Engineer.

13. Reinforcing Steel

Before being placed in position all reinforcing steel shall be cleaned thoroughly of loose mill and rust scale, grease, paint, or other coatings of any character that will destroy or reduce the bond. A reinforcing bar that shows a slight film of rust so as not to break the bond between the steel and the concrete supplies a better bond than a highly-polished surface, as the action of rust roughens the surface of the bar and actually results in greater bond strength. All splashed concrete that has dried on the reinforcing shall be removed. Reinforcements shall be thoroughly secured in position and approved by the Engineer.

14. Mixing

(a) *Machine Mixing*

The mixing of the concrete shall be done in a batch mixer of the drum type approved by the Engineer. The

mixing equipment shall be capable of combining the aggregate, cement and water within the specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation. The entire contents of the drum shall be discharged before recharging. The mixer at intervals shall be cleaned of any hardened concrete which may form on the inside of the drum. The mixer shall be of adequate size to accommodate the maximum batch, and shall be in accordance with the Standards adopted by the Mixer Manufacturers' Bureau of the Associated General Contractors of America. The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregate and all shall continue to flow in as rapidly as practicable. Loss of materials during charging will not be permitted. The mixer shall not be operated unless the water-measuring device is functioning properly, nor when leaking valves pass unmeasured water into the drum. Whenever a pick-up and throw-over blade in the drum has become worn so that its area is reduced by not more than twenty-five per cent, or by a lesser amount if, in the judgment of the Engineer, the wear is too great, it shall be replaced with new blades in accordance with the mixer manufacturer's recommendations.

(b) *Time of Mixing and Revolutions*

For mixers of one cubic yard or less the mixing of each batch shall continue for not less than one and one-half minutes after all ingredients are in the drum. For mixers of a larger capacity this time shall be increased at the rate of 15 seconds or more for each additional cubic yard. The mixer shall be rotated at a rate recommended by the manufacturer, but shall not make less than nine and one-half, nor more than twenty revolutions per minute.

(c) *Hand Mixing*

When hand mixing is authorized by the Engineer, 10 per cent extra cement over and above that required for volume measurement shall be used. Hand mixing shall be carried out on a water-tight platform and care shall be taken to ensure that the mixing is continued until the mass is uniform in colour and consistency.

(d) *Re-tempering*

The re-tempering of concrete or mortar which has partially hardened, that is, remixing with or without additional cement, aggregate or water, will not be permitted unless authorized by the Engineer in specific instances.

(e) *Consistency*

The Engineer shall determine and specify the consistency of the concrete on the various portions of the work. At no time shall it be so dry that the concrete cannot be placed in the forms satisfactorily by methods available on the job; or, where reinforcement is being used, that it cannot be worked in around the reinforcement. Concrete mixtures that are so wet as to segregate in the hoppers, chutes, or forms will not be permitted.

(To be continued.)

Sun-Spot Disturbances of Terrestrial Magnetism

By W. F. Davidson, Director of Research, Consolidated Edison Company of New York, Inc., New York, N.Y.

ALTHOUGH communication engineers have long recognized the existence of magnetic storms or disturbances in the normal magnetic field of the earth, power engineers generally have not been aware of the fact that the storms could reach sufficient magnitude to cause operating disturbances in electric-power systems. Consequently, when on March 24, 1940, a number of power systems in the United States and Canada experienced operating difficulties coincident with the onset of a magnetic storm, the subject received widespread comment. The present discussion is a brief summary of power-system experience with some notes on the general subject of magnetic storms and the theories that have been advanced to explain them. For the latter, the author is indebted to Doctor A. G. McNish of the department of terrestrial magnetism, Carnegie Institution of Washington and particularly to the material he prepared for presentation before a recent meeting of the engineering committees of the Edison Electric Institute. The information on power systems was obtained chiefly through responses to letters sent out by the Edison Electric Institute. Valuable information on the effects of the storm on communication systems have been supplied by L. W. Germaine, long lines department, American Telephone and Telegraph Company.

Power systems reporting disturbances are located in New England, New York, eastern Pennsylvania, southern and eastern parts of Minnesota, Ontario, and Quebec. On the ten systems on which disturbances were noted, the effects listed in the inverse order of the number of cases reported were:

1. Voltage dips ranging up to ten per cent, but generally of short duration (seven cases).
2. Tripping transformer banks by differential relay operation (five cases involving 15 transformer banks).
3. Large increases or swings in reactive kilovolt-amperes (four cases).

In addition, we have three separate observations:

1. Direct current was measured in a neutral grounding (one case).
2. Distortion of the current wave in a neutral grounding connection was recorded by oscillograph (one case).
3. A few blown transformer fuses on a 2,400/4,150-volt radial distribution system (one case).

No serious operating difficulties or interference with service were reported, possibly because it was Easter Sunday and loads were unusually light.

The instances of transformer tripping are probably of first importance because they present the largest potential possibility of interference with service. Examples are (eastern standard time throughout):

Two 75,000-kv-a. transformer banks on the 220-kv. system of the Philadelphia Electric Company-Public Service Corporation of New Jersey-Pennsylvania Power and Light Company, eastern Pennsylvania and New Jersey, tripped out by differential relay operation at 11.48 a.m. At about the same time, there were voltage swings of about 1½ per cent and reactive power surges of about 20 per cent.

On the 220-kv. system of the Niagara District, Ontario Hydro-Electric Commission, four transformer banks were tripped out by differential relay operation at 11:48 a.m.

On the 132-kv. Abitibi system of the Ontario Hydro-Electric Commission, six transformer banks tripped out by differential relay operation at 11:48 a.m.

The 40,000-kv-a. transformer bank connecting the 11-kv. and 110-kv. systems of the Narragansett Electric Company in Providence, R.I., were tripped out by differential relay operation. Shortly after this, an ammeter was connected in the transformer neutral and a direct current of 25 amperes was recorded. At the time of this observation, no operating difficulties were being experienced.

Two transformer banks operating from the 110-kv. lines of the Central Maine Power Company at Bucksport were tripped out by differential relay operation at about 11:15 a.m. with accompanying voltage dips as large as eight per cent.

Some mention already has been made of reactive power surges and voltage dips. Other cases where these phenomena were observed, but without causing equipment outage, include the following:

On the system of the Northern States Power Company centering about Minneapolis, Minn., there was 105,000 kw. of steam generating capacity in service in stations in the Minneapolis area and another 10,000 kw. at Minnesota Valley, roughly 100 miles to the west. Two 10,000-kv-a. synchronous condensers were operating in the Minneapolis area and one 5,000-kv-a. synchronous condenser at Mankato about 100 circuit miles to the southwest. Transmission circuits involved were principally 69 kv. with transformer banks generally wye-delta with grounded neutrals on the 69-kv. side. In addition there are a few autotransformers connecting to the 115-kv. system, these having delta-connected auxiliary windings. With few exceptions single transformers are used. The first disturbance in the nature of a surge as indicated by shift of load on the synchronous condensers was observed at about 10:45 a.m This was followed by numerous other surges at irregular intervals until 1:45 p.m. There was a slight recurrence of minor severity between 10:30 a.m. and 12:15 p.m. The most severe of the surges occurred at about 11:50 a.m. when the total build-up and decay period seemed to cover about four minutes. During that time the synchronous condensers which were operating on voltage regulators shifted load from maximum buck to maximum boost and return. There was an accompanying drop in voltage of about ten per cent. Considerable surges in reactive

component on several of the circuits such as the Wissota-Oak Park 115-kv. line where a change of 10,000 reactive kv-a. was recorded. The graphic wattmeters showed no corresponding indication of the disturbances, and there were no circuit breaker operations. At Sparta, Minn., approximately 150 miles to the south-east of Minneapolis, the 69-kv. line-regulation transformer operated to the extreme position in each direction and a lightning arrester discharge was noted.

On the Newburyport-Haverhill 22-kv. double-circuit line of the Eastern Massachusetts Electric Company, the current was in the order of eight amperes, or about the charging current of the line, until late in the morning when the disturbances began. At that time swings to as high as 60 amperes or somewhat more than normal full-load current, were observed. Individual swings had a duration of a minute or less but recurred at frequent intervals over a period of some 10 or 15 minutes. There was considerable accompanying voltage drop.

On the Consolidated Edison 60-cycle system in New York, N.Y., a series of voltage disturbances took place beginning about 11:48 a.m. The first dip, which varied from 1½ per cent to 10 per cent in different parts of the system, was followed by a series of minor dips continuing at short intervals for a period of about one hour. The 25-cycle system voltage was not affected nor was there any appreciable change in system frequency or change in load in any part of either system. The voltage dips were of lower magnitude than those often caused by high-voltage feeder faults and did not have any serious effect on operation of customers' equipment or on the operation of the system. An analysis of available data indicates that on the 60-cycle system, the increase in reactive load was in the order of 45,500 reactive kv-a.

On the 110-kv. system of the Niagara Hudson Power Corporation, there were numerous operations of an automatic oscillograph installed at Lockport, N.Y. A study of some of the records show that the neutral current has the characteristic wave form obtained with transformer operating with direct current superimposed on the alternating-current excitation, but since the oscillograph was operated through a current transformer, there was no direct observation of direct current.

The Boston Edison Company reported a considerable number of blown transformer fuses on its 2,400/4,150-volt radial distribution system. All were on transformers at the ends of feeders at points where the neutral was continued past open tie switches to feeders in adjacent areas.

For the purpose of explaining what happened in the power systems, I shall refer chiefly to the New York system, for which an extensive analysis has been made. It was noted that:

1. There had been voltage dips of short duration and considerable magnitude.
2. There had been increases in reactive kilovolt-amperes coincident with the

voltage dips and proportionate to them.

3. There had been no appreciable change in the power components, that is, in kilowatt load.

These phenomena were, at least qualitatively, what would be expected if direct currents flowed in the windings of transformers so as to cause saturation and lead to increased a.c. magnetizing currents.

H. B. Seeley of Consolidated Edison Company, has made a number of calculations in which he has used test data showing the effect of superimposed direct currents on transformer characteristics and has made the assumption of an earth-potential gradient of 10 volts per mile. He also used in his calculations the known electrical characteristics of typical feeders on the radial distribution system. The result is a calculated increase of 26.4 reactive megavolt-amperes compared with an observed 25—a convincing argument as to the validity of explanation.

With this analysis in mind, we can explore some of the other cases, for example, the interconnected 69-115-kv. system of the Northern States Power Company. The test data previously mentioned would lead one to expect that each ampere of direct current in the 69-kv. windings of single-phase transformers would cause 75 reactive kv-a. increase, and each ampere in 115-kv. windings would cause 125 reactive kv-a. increase in excitation. Assuming an average of these two values, it follows that only about 0.75 ampere of direct current in the neutral for each 1,000 kv-a. of transformer capacity would be necessary to explain the observed increase of 30 reactive megavolt-amperes on about 400 megavolt-amperes of transformer capacity.

The disturbances in which transformer banks tripped on differential relay operation require no extended analysis. If direct current flows in one winding, it will not induce a corresponding current in the other, and in consequence single-phase transformers will have a steady magnetic flux in one direction which in turn will lead to saturation and increase the magnetizing component. The magnitude of this unbalanced component has been indicated in the previous discussion; for a 220-kv. transformer one ampere of direct current will cause an increase of about 200 reactive kv-a. in the magnetizing component, which appears as an unbalance at the differential relays. Coupled with this there will be a distortion of the wave form as indicated by the oscillograph. Insufficient data are available to permit making a statement as to the effect of this distortion on relay performance, but it seems probable that the effects will be generally in the direction of increasing the apparent sensitivity, thus further decreasing the amount of actual unbalance necessary to cause relay tripping.

Some thought has been given to the effects of direct currents on the ratio and phase angle of instrument transformers, but all of the test data so far examined suggest that the effects are of secondary importance. Instrument transformers generally operate at comparatively low magnetic flux densities, and in consequence they are far less susceptible than power transformers to the disturbing effects of superimposed direct currents. Relatively large d.c. components are necessary to make

a five per cent change in ratio of current transformers or to cause a similar error in the ratio of potential transformers.

In seeking further light on the underlying phenomena involved in the magnetic storm, we may next turn to the data collected by the Bell Telephone system. Like the telegraph companies, telephone companies have long been aware of magnetic storms and have taken steps to place instruments so that records of their currents could be observed. Many recording voltmeters are in continuous operation connected between ground points at various central offices. From an analysis of their records, it is known that potential differences of 400 volts or more occurred between numerous line terminals. One of the most serious effects of these disturbing voltages was the operation of the protective devices installed in central offices at the juncture of open-wire and cable plant. In numerous cases, the voltages continued at such high values that the protective devices operated as fast as they were closed, making it impossible to use the circuits. In other cases, intermediate discharges across the gap of the protective devices were so frequent and severe as to make the circuits noisy and not satisfactory for service.

Analysis of the data obtained during this particular storm confirms earlier observations which show that the largest potential gradients occurred in areas known to have high earth resistivity. It may be observed that these areas are the same ones in which power-system disturbances were noted.

Coming now to the matter of a more fundamental explanation of the nature of the magnetic storms, we find that we enter a field of speculation in spite of the enormous mass of exact scientific data that has been accumulated during the past century or more. For many years, magnetic observatories distributed throughout the world have been accumulating information on the earth's magnetic field. From these it is known that there are continual changes not only from day to day but from hour to hour; usually these changes are so small as to produce no noticeable effect even in communication circuits with earth return. However, during the periods of magnetic storm, the changes become very much greater. Some idea of their magnitude may be gained from Doctor McNish's calculation that during the great magnetic storm of April 1938, energy was expended at the rate of 2,000,000,000 kw. for a two-hour interval. The storm of two years later appears to have been even more intense so it is not surprising that there were effects even on power systems of 2,000,000 kw. connected capacity.

To quote now from Doctor McNish: "Mathematical analysis has shown that field changes during magnetic storms are due principally to causes above the earth's surface, presumably electric currents, and that these external effects are accompanied by effects due to the induction of currents within the earth by the primary external fields. It is an unfortunate limitation of mathematical analysis that it cannot describe uniquely both the location and configurations of these external currents, although with the assistance of mathematical analysis and some other considerations one may deduce probable

locations and configurations. The field changes may be divided into two classes—those which are symmetric about the earth's magnetic axis and those which are non-symmetric. The first class may be thought of as due mainly to a large ring current about the earth, like the rings of Saturn, or to a current flowing in the outer atmosphere with intensity varying as the cosine of the geomagnetic latitude from zero at the geomagnetic poles to a maximum at the equator. The inferences we may draw from magnetic observations are entirely ambiguous in this regard for they permit either possibility. If the ring current is the correct conception its radius may be several times that of the earth. During the first phase of a magnetic storm the current in this ring flows from west to east and during the main or second phase it flows from east to west; the magnitude of the current reaches several million amperes at its maximum during great magnetic storms. Although the greater part of the energy of magnetic storms is involved in this hypothetical ring current, the magnetic changes are not rapid enough to induce the very high potentials within the earth which play havoc with electric systems.

"The second class of field changes, which are nonsymmetric about the earth's geomagnetic axis, are associated with electric currents flowing with maximum intensity along the auroral zone. There is every assurance that these currents are confined to our atmosphere, probably at a height of about 100 kilometers or so, where radio observations and auroral phenomena attest that the atmosphere is highly ionized. Field changes arising from these currents are responsible for the effects on communication and power lines.

"Observation of the field changes at a number of stations during various magnetic storms has permitted mapping of typical current-circulations. In general, these consist of intense currents flowing in an east-west direction along the auroral zone with diffuse return circulations—also confined to the atmosphere—across the polar cap and in low latitudes. Westward currents predominate on the morning side of the earth and eastward currents on the afternoon side, the westward currents being in general more intense. Such currents may continue for an hour or several hours but rapid changes in their intensity take place. Obviously, with such a distribution of currents, although a magnetic storm may be occurring all over the earth, certain places will be subject to more intense disturbance depending upon the location of the place and the time of day at which the magnetic storm began. The strength of these auroral-zone currents may exceed 1,000,000 amperes and changes exceeding 100,000 amperes in one minute have been observed. Although the path may be 100 miles or so in width, to a first approximation it may be regarded as confined to a vast trolley-wire stretching for hundreds of miles in an east-west direction at a height of about 100 miles above the earth.

"The cause of the primary electric currents in the outer atmosphere or about the earth remains a matter of speculation. We know definitely that solar activity is directly responsible for magnetic storms—magnetic storms vary

in frequency with the sun-spot cycle and exhibit a quasi-periodic effect which is associated with the sun's rotation."

Finally, a word as to "what to do about it." The record of past years indicates that while there will be recurrence of magnetic storms of great magnitude, their effects probably will be no greater than just described. What the effects on service might be is for others to say. Possibly they are serious enough to justify a review of differential relaying to determine whether changes can be made that will reduce the sensitivity as steady d.c. components in the neutral increase.—*Electrical Engineering.*

T. E. BELL, Mimico

Thomas Ellison Bell, superintendent of the Mimico Utilities Commission, passed away on Thursday, April 24th, 1941, aged fifty-six years.

He was a native of Belfast, Ireland, born in 1885, and lived there until he came to Canada in 1905. Before leaving Ireland he served for a time with the National Telephone Company at Belfast. Entering the employ of the Toronto Electric Light Company at Toronto, he stayed there until 1914 when he became a foreman on overhead, wood-pole construction with The Hydro-Electric Power Commission of Ontario at 32½ cents an hour, working 10 hours a day. In 1917 he left the Commission to accept the position of superintendent of the Mimico Public Utilities Commission where he served until his death.

In the discharge of his duties, Mr. Bell was an efficient and devoted servant of his employers and proved himself a capable superintendent who was well liked.

N. A. ANDERSON
Niagara-on-the-Lake

Nelson Alexander Anderson, superintendent and secretary-treasurer of the Niagara Hydro-Electric Commission died on Tuesday, April 22nd, 1941. He was in his 55th year.

He was born and raised at Port Elgin, Ontario. In 1912 he entered the employ of The Hydro-Electric Power Commission of Ontario on line construction and clerical work, coming from Hamilton where he had been similarly engaged. In 1914 he went to Brantford Hydro-Electric System, and from there, in 1915, to Niagara. With the exception of two years at Sudbury, he resided at Niagara since that time. Starting as a lineman, he soon rose to the position of superintendent and of later years became also secretary-treasurer of the local commission. In the performance of his duties he won the esteem of all with whom he came in contact.

In his youth Mr. Anderson was an outstanding lacrosse player, and he always took a keen interest in all lines of sports. At the time of his death he was president of the Niagara Bowling Club. He was also an outstanding golf player.

Although he had been in poor health for some years, his death came as a great shock to the people of the town where he was well and favourably known, as also in Hydro circles generally.

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Welcome to A.I.E.E.

By Dr. Thomas H. Hogg, Chairman and Chief Engineer, The Hydro-Electric Power Commission of Ontario

IT IS indeed a pleasure and an honour to extend to the members of the American Institute of Electrical Engineers, meeting for the third time in Canada, a most cordial welcome.

Twice before, if I recall correctly, has the summer convention of the American Institute of Electrical Engineers been held in Canada; in 1922 at Niagara Falls, Ontario, and in 1930 it came as far as Toronto. The 1930 convention was a great success and as a result we in Canada are again privileged and happy to be hosts to our fellow engineers from south of the border.

When we met in 1930 we were facing, though few of us then recognized it, the long lean years of the depression, the most severe in modern times. This was indeed a testing time for all, especially those engaged in production and in construction, spheres in which engineers play such an important part. Many new problems were presented by these conditions and the engineer was forced by circumstances to consider economic and financial matters to a greater extent than ever before. I believe the engineering profession helped materially to guide the ship of state through these troubled waters, and that, in the new economic and social horizons that are opening before us, the engineer will be forced, often against his inclination, to spend more time on the bridge and perhaps less in the engine room.

Meantime we have a big job to do. Canada today is at war, fighting for those principles of freedom, for the rights of self-government and of liberty, for which our forefathers struggled through the centuries; today, in fact, we are fighting for our lives and the lives of our families.

The tools of war today are provided by science and engineering, but these

Address to Convention of the American Institute of Electrical Engineers at Toronto on June 17, 1941.

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sciences, unfortunately, have been perverted by evil men, planning over long years to employ gangster methods, in order that they may become slavemasters dominating the world. These men must and will be defeated. They can be defeated by the wholehearted and enduring efforts of the democracies of the world. But since the tools of war and of defence are produced largely by engineers, there rests upon us, the engineers of democracies, a very special and important responsibility. No doubt this thought will form a background to much of the discussion of this 1941 convention.

Today our brothers in the British Isles are fighting the forces of evil with a courage and morale of which we are all proud. Let us not forget, therefore, that on this continent our ability to go and come as we wish, and within reason to do and say what we wish, rests today upon the fact that in her island fortress British airmen have been able to hold their own, and on the seven seas the British Navy still functions effectively. These things are so because for many years past conscientious engineers and scientists have been quietly but effectively developing machines and equipment that individually have proved themselves superior to those of our enemy. Behind the men and women of Britain who are in the front line, stands every Dominion in the Commonwealth of British Nations and to an ever-growing extent the aid of our great neighbour to the south.

For more than a hundred years there has existed between our two countries a bond of friendship and a sincere willingness to share in the progress and development of both nations. Today we in Canada feel that in facing the common dangers of a titanic struggle, this bond is being strengthened, so that, more and more, we are united by a common ideal in the desire to preserve our national and personal freedom and the right to "life, liberty and the pursuit of happiness" for our peoples. In our countries there exists as never before a unity of purpose and effort directed to securing a successful conclusion to a vital struggle. Engineers of Canada and the United States will be called upon to employ their experience, and whatever specialized knowledge they may possess, so that by the efficient mobilization of the great resources of the two countries a continuous stream of munitions and supplies of all kinds may be directed through

unimpeded channels to their appointed destination.

The highest achievement in scientific and technical matters cannot be attained except where the utmost freedom of thought and co-operative action are permitted. So today we are proud and happy to welcome you as our guests for a short time. We believe that the friendships that will result from this meeting, the interchange of knowledge and the discussion of ideas, will benefit us both personally and nationally. To the world, we can demonstrate the merits of friendly relations and the value of sharing knowledge, which will thus permit the beneficial use of the arts and sciences and enable them to take their rightful place in furthering the freedom, and happiness and well-being of the peoples of the earth.

On behalf of the engineering profession of Canada and the electrical industry of the Province of Ontario, I extend to you a most hearty welcome.

Domestic and Commercial Lighting Revenue and Consumption of all Hydro Municipalities

THE growth in consumption and revenue from year to year for all domestic and all commercial consumers is shown in the following tables. Also, both domestic and commercial consumers are divided into tables showing totals for cities with a population of 10,000 or more, towns with a population of over 2,000 and villages with a population under 2,000. The tables include all the municipalities as shown in Statement "D" of the Annual Report, as well as those municipalities owned and operated by the H.E.P.C.

Domestic Service

Table No. I shows a steady increase in the use of electricity by city domestic consumers. The average monthly consumption rose from 188.3 kw-hr. in 1939 to 193.8 kw-hr. in 1940. The average cost per kilowatt-hour was 1.16 cents in 1940.

Table No. II shows that domestic consumers in towns have increased their average consumption from 143.1 kw-hr. in 1939 to 153.0 kw-hr. in 1940 and average cost has dropped to 1.38 cents in 1940.

Table No. III shows that domestic consumers in villages have an average consumption of 114.6 kw-hr., with an average cost of 1.73 cents in 1940.

Table No. IV gives a summary of all domestic consumers in all municipalities and may be compared with its component parts for the year 1940, as follows:

	Average Cost per Kw-hr.	Average Monthly Bill	Av. Monthly Consumption Kw-hr.
All Domestic Consumers	1.25c	$2.18	174.9
Cities	1.16	2.24	193.8
Towns	1.38	2.08	153.0
Villages	1.73	1.98	114.6

TABLE No. I

DATA FOR CITIES OVER 10,000 POPULATION

DOMESTIC SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Con-sumers	Average Cost per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	12	$ 614,925.00	12,646,400	55,597	4.86c	$1.06	21.8
1917	19	1,063,264.00	36,693,100	107,248	2.89	.88	30.5
1920	21	1,926,924.00	84,328,000	154,186	2.29	1.11	48.4
1923	21	3,772,416.00	206,266,200	223,028	1.83	1.53	83.5
1926	21	5,374,069.00	324,290,285	255,109	1.66	1.80	108.0
1930	26	7,921,316.00	541,876,998	315,611	1.46	2.11	144.4
1933	26	8,495,321.93	595,211,863	330,597	1.43	2.14	150.0
1936	26	9,743,001.62	720,002,863	350,083	1.35	2.32	171.4
1939	26	9,672,757.10	827,446,879	366,179	1.17	2.20	188.3
1940	26	10,064,709.22	865,971,948	373,855	1.16	2.24	193.8

TABLE No. II

DATA FOR TOWNS OVER 2,000 POPULATION

DOMESTIC SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Con-sumers	Average Cost per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	19	$90,330.00	1,414,500	7,410	6.38c	$1.11	17.4
1917	27	180,075.00	3,824,600	15,731	4.71	1.01	21.4
1920	36	353,915.00	10,053,100	24,041	3.50	1.26	36.0
1923	43	651,499.00	25,411,300	34,135	2.56	1.57	60.1
1926	48	1,037,016.00	50,487,035	47,873	2.05	1.84	89.6
1930	53	1,468,194.00	73,234,125	58,490	2.01	2.10	105.0
1933	60	1,584,772.57	82,321,996	63,910	1.92	2.07	107.3
1936	57	1,460,916.64	80,678,385	61,102	1.81	1.99	110.1
1939	63	1,785,220.67	124,373,708	72,441	1.44	2.05	143.1
1940	64	1,884,922.20	137,002,007	75,460	1.38	2.08	153.0

TABLE No. III

DATA FOR VILLAGES UNDER 2,000 POPULATION

DOMESTIC SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Con-sumers	Average Cost per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	18	$ 24,913.00	291,000	1,859	9.55c	$1.10	13.1
1917	77	97,516.00	1,412,500	8,334	6.90	.96	14.0
1920	109	233,819.00	3,829,900	15,665	6.00	1.29	21.2
1923	142	531,505.00	11,249,100	29,689	4.72	1.59	33.7
1926	174	942,309.00	29,945,632	46,900	3.15	1.71	54.4
1930	194	1,363,210.00	55,917,187	59,159	2.43	1.95	80.1
1933	214	1,559,083.62	64,651,543	66,371	2.41	1.96	81.2
1936	219	1,718,548.21	81,291,076	71,372	2.11	2.01	94.9
1939	228	1,842,920.38	104,489,522	79,503	1.76	1.93	109.5
1940	227	1,955,659.04	112,914,882	82,199	1.73	1.98	114.6

TABLE No. IV
ALL MUNICIPALITIES TOTALLED
DOMESTIC SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Con-sumers	Average Cost per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	49	$730,168.00	14,359,100	64,866	5.08c	$1.06	21.0
1917	123	1,340,855.00	41,930,200	131,313	3.20	.91	28.6
1920	166	2,514,658.00	98,211,000	193,892	2.56	1.15	44.6
1923	206	4,955,420.00	242,926,600	286,852	2.04	1.54	75.7
1926	243	7,353,394.00	404,722,929	349,882	1.81	1.79	98.4
1930	273	10,752,720.00	671,028,310	433,260	1.61	2.09	130.1
1933	300	11,639,178.12	742,195,402	460,878	1.57	2.10	134.2
1936	302	12,922,466.47	881,972,324	482,557	1.47	2.23	152.3
1939	317	13,300,898.15	1,056,310,109	518,123	1.26	2.14	169.9
1940	317	13,905,290.46	1,115,888,837	531,514	1.25	2.18	174.9

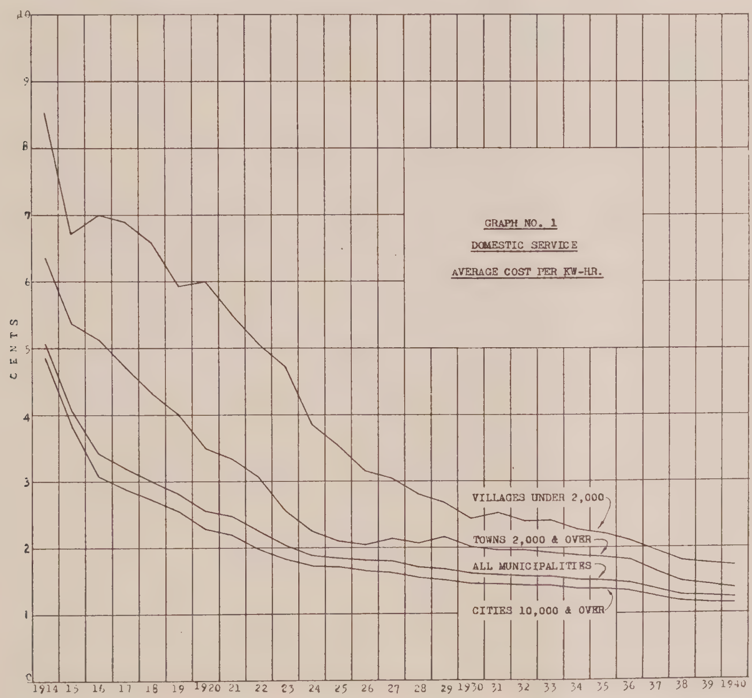
It will be noted that the average cost per kilowatt-hour for all domestic consumers was 2.56 cents in 1920; 1.61 cents in 1930 and 1.25 cents in 1940.

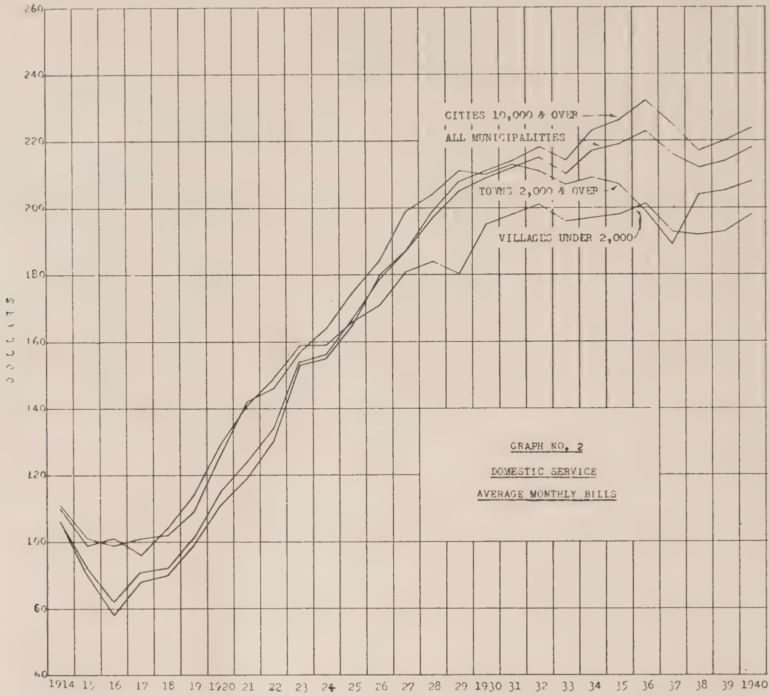
The growth in the use of electricity by domestic consumers is also illustrated by graphs.

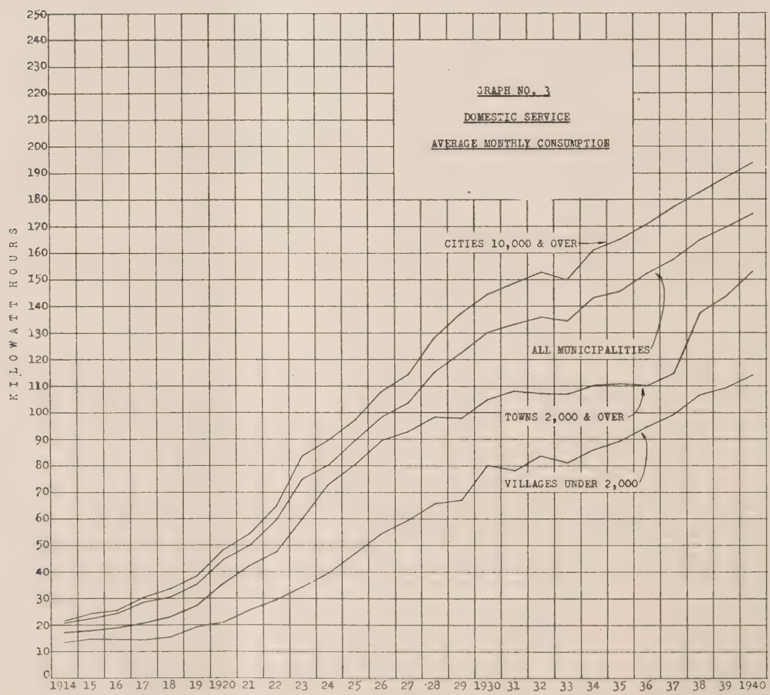
Graph No. 1 shows the average cost per kilowatt-hour as given in Tables Nos. I, II, III and IV.

Graph No. 2 gives the variations in the average monthly bills from the same tables.

Graph No. 3 shows the growth in the average monthly consumption.




CITIES 10,000 & OVER
ALL MUNICIPALITIES
TOWNS 2,000 & OVER
VILLAGES UNDER 2,000
GRAPH NO. 2
DOMESTIC SERVICE
AVERAGE MONTHLY BILLS
DOLLARS
1914 15 16 17 18 19 1920 21 22 23 24 25 26 27 28 29 1930 31 32 33 34 35 36 37 38 39 1940


GRAPH NO. 3
DOMESTIC SERVICE
AVERAGE MONTHLY CONSUMPTION
CITIES 10,000 & OVER
ALL MUNICIPALITIES
TOWNS 2,000 & OVER
VILLAGES UNDER 2,000
KILOWATT HOURS
1914 15 16 17 18 19 1920 21 22 23 24 25 26 27 28 29 1930 31 32 33 34 35 36 37 38 39 1940

Commercial Lighting Service

The tables and graphs on the revenue and consumption of commercial consumers show the effect of improved store lighting and industrial conditions.

Table No. V shows a 25,000,000 increase in kilowatt-hours used by commercial lighting consumers in cities during 1939 and a 40,000,000 increase in 1940. The average monthly consumption in 1940 was 650.8 kw-hr. and the average cost per kilowatt-hour 1.45 cents.

Table No. VI gives similar data for towns.

Table No. VII gives similar data for villages.

Table No. VIII is a summary of all commercial lighting consumers and may be compared with its component parts, as follows:

	Average Cost per Kw-hr.	Average Monthly Bill	Av. Monthly Consumption Kw-hr.
All Commercial Lighting Consumers	1.53c	$8.16	533.4
Cities	1.45	9.46	650.8
Towns	1.64	6.27	381.4
Villages	2.24	4.76	212.8

The average cost per kilowatt-hour for all commercial lighting consumers was 2.5 cents in 1920; 2.11 cents in 1930 and 1.53 cents in 1940.

The results shown in Tables Nos. V, VI, VII and VIII are graphically illustrated in Graphs Nos. 5, 6 and 7.

TABLE No. V
DATA FOR CITIES OVER 10,000 POPULATION
COMMERCIAL LIGHTING SERVICE

Year	No. of Municipalities	Annual Revenue	Kilowatt-hours Consumed	Number of Consumers	Average Cost per Kw-hr.	Average Monthly Bill	Average Monthly Consumption Kw-hr.
1914	12	$536,350.00	14,048,500	12,439	3.80c	$3.94	103.7
1917	19	642,989.00	27,479,800	19,573	2.34	2.96	126.6
1920	21	1,103,599.00	50,358,000	25,505	2.19	3.77	172.0
1923	21	2,043,197.00	91,146,500	32,016	2.25	5.56	246.9
1926	21	3,393,186.00	147,581,714	40,675	2.30	7.08	308.0
1930	26	4,919,496.00	242,278,308	50,046	2.03	8.31	409.6
1933	26	4,910,798.54	242,854,622	51,769	2.02	7.90	390.9
1936	26	5,673,317.44	298,250,755	52,058	1.90	9.08	477.4
1939	26	5,681,059.37	378,726,206	53,383	1.50	8.87	591.2
1940	26	6,089,053.86	418,673,481	53,611	1.45	9.46	650.8

TABLE No. VI

DATA FOR TOWNS OVER 2,000 POPULATION

COMMERCIAL LIGHTING SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Con-sumers	Average Cost per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	17	$71,457.00	1,362,000	2,393	5.25c	$2.61	49.8
1917	27	134,730.00	3,100,600	4,107	4.35	2.76	63.5
1920	36	221,867.00	6,179,400	5,736	3.59	3.30	91.8
1923	43	315,530.00	9,598,000	7,086	3.29	3.76	114.3
1926	48	430,467.00	15,709,616	8,310	2.74	4.31	160.0
1930	54	661,857.00	27,841,568	10,274	2.38	5.38	226.4
1933	60	663,596.72	29,864,388	10,966	2.22	5.04	226.9
1936	57	687,355.93	32,957,583	10,600	2.09	5.40	259.1
1939	63	820,003.15	48,244,514	11,669	1.70	5.85	344.5
1940	64	899,111.24	54,678,056	11,947	1.64	6.27	381.4

TABLE No. VII

DATA FOR VILLAGES UNDER 2,000 POPULATION

COMMERCIAL LIGHTING SERVICE

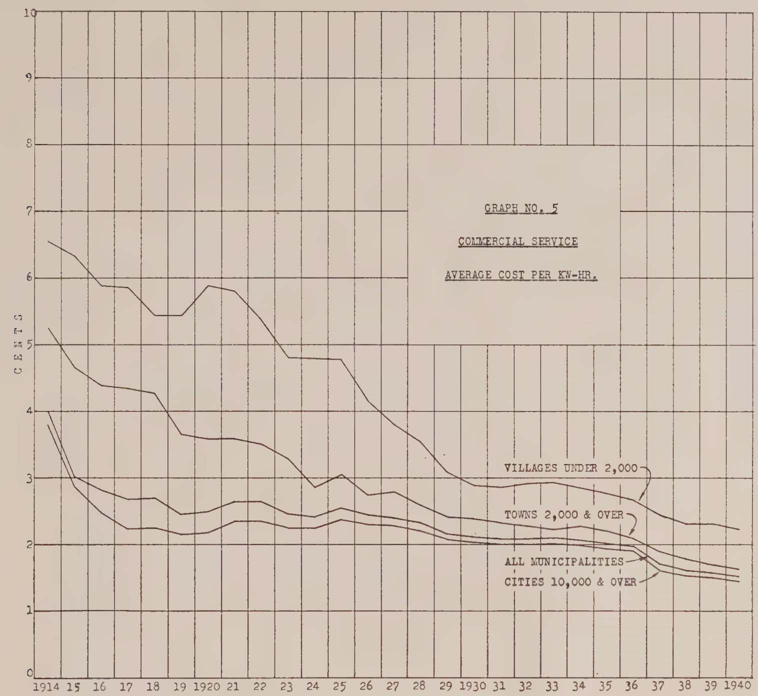
Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Con-sumers	Average Cost per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	14	$16,974.00	259,200	825	6.55c	$1.74	26.6
1917	77	82,756.00	1,403,100	3,773	5.86	1.87	31.7
1920	109	152,497.00	2,799,500	5,255	5.89	2.45	45.0
1923	142	254,530.00	4,738,100	7,281	4.80	2.96	55.1
1926	173	352,942.00	8,505,684	9,459	4.15	3.22	77.7
1930	193	513,518.00	17,718,146	11,553	2.89	3.76	129.9
1933	214	575,396.85	19,616,479	12,708	2.93	3.77	128.6
1936	219	641,220.20	24,027,215	13,220	2.67	4.04	151.5
1939	228	755,199.53	32,664,380	13,997	2.31	4.50	194.5
1940	227	796,858.90	35,634,885	13,954	2.24	4.76	212.8

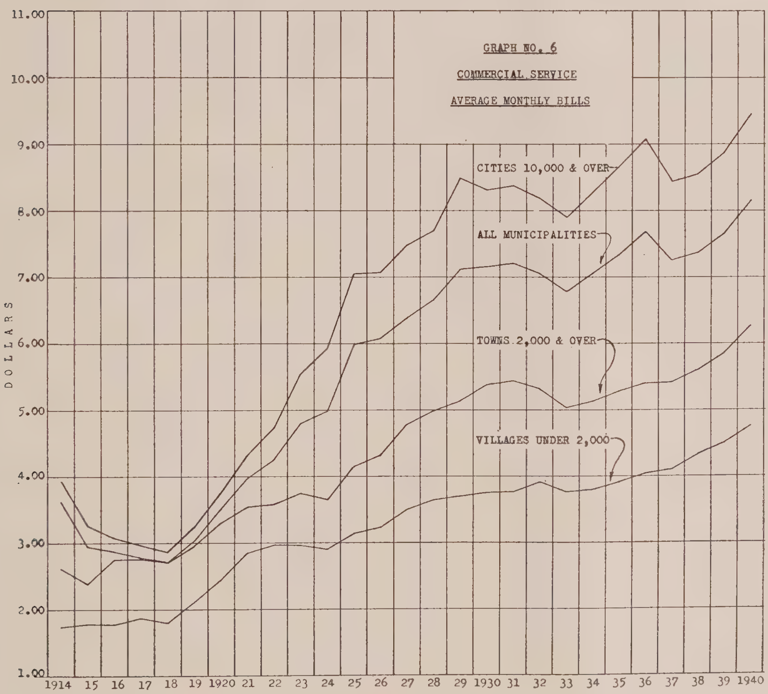
TABLE No. VIII

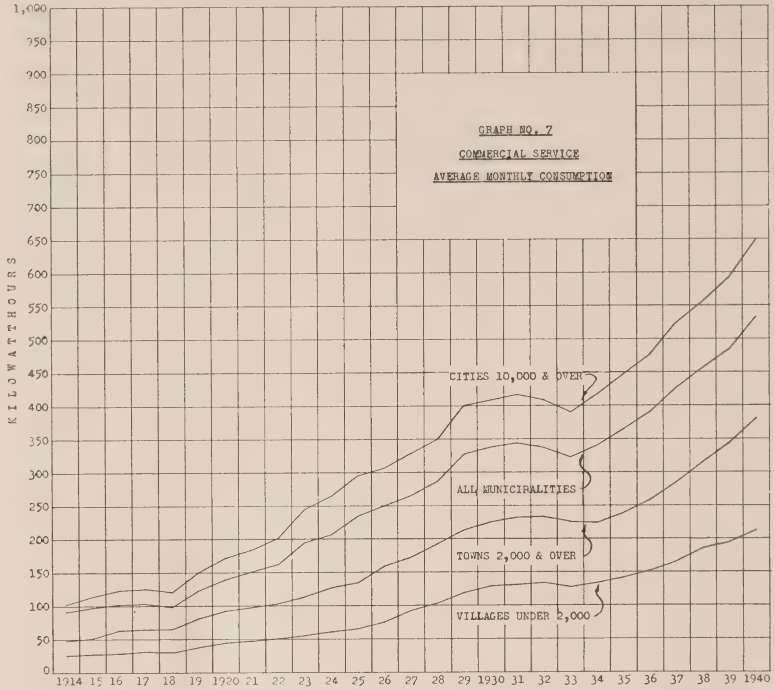
ALL MUNICIPALITIES TOTALLED

COMMERCIAL LIGHTING SERVICE

Year	No. of Munici-palities	Annual Revenue	Kilowatt-hours Consumed	Number of Con-sumers	Average Cost per Kw-hr.	Average Monthly Bill	Average Monthly Consump-tion Kw-hr.
1914	43	$624,781.00	15,669,700	15,657	4.00c	$3.63	90.8
1917	123	860,475.00	31,983,500	27,453	2.69	2.77	103.1
1920	166	1,477,963.00	59,336,900	36,496	2.50	3.51	140.0
1923	206	2,613,257.00	105,482,600	46,383	2.46	4.80	195.6
1926	242	4,176,595.00	171,797,014	58,444	2.43	6.08	250.0
1930	273	6,094,871.00	287,838,022	71,873	2.11	7.15	337.8
1933	300	6,149,792.11	292,335,489	75,443	2.10	6.79	322.9
1936	302	7,001,893.57	355,235,553	75,878	1.97	7.69	390.1
1939	317	7,256,262.05	459,635,100	78,949	1.58	7.66	485.2
1940	317	7,785,024.00	508,986,422	79,512	1.53	8.16	533.4


GRAPH NO. 5
COMMERCIAL SERVICE
AVERAGE COST PER KW-HR.
CENTS
VILLAGES UNDER 2,000
TOWNS 2,000 & OVER
ALL MUNICIPALITIES
CITIES 10,000 & OVER
0
1
2
3
4
5
6
7
8
9
10
1914 15 16 17 18 19 1920 21 22 23 24 25 26 27 28 29 1930 31 32 33 34 35 36 37 38 39 1940


GRAPH NO. 6
COMMERCIAL SERVICE
AVERAGE MONTHLY BILLS
DOLLARS
CITIES 10,000 & OVER
ALL MUNICIPALITIES
TOWNS 2,000 & OVER
VILLAGES UNDER 2,000
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
1914 15 16 17 18 19 1920 21 22 23 24 25 26 27 28 29 1930 31 32 33 34 35 36 37 38 39 1940



Preliminary Suggestions on Tree Clearance

WE have been handed a copy of a report prepared by the Tree Clearance Subcommittee and Distribution Committee of the Edison Electric Institute which was presented for Committee approval at the Chicago meeting of May 5th, 6th and 7th, 1941. As stated in the report, it outlines suggestions developed by the subcommittee during 2½ years of study, and we understand it has been drawn up to conform with the best practices of electric utilities operating in the United States. The publication of the report herein does not imply that it has received approval of The Hydro-Electric Power Commission of Ontario, but we believe it contains information and instructions that should prove useful to a large number of our readers who have to give serious consideration to maintaining adaquate line clearances in treed areas.

* * * *

These suggestions have been developed by the subcommittee from its 2½-year study of the economic and physical aspects of tree interference in the construction, maintenance and operation of overhead electric lines. They are intended as information to

EXHIBIT 1

Type	Species Common Name	*Avg. Annual Growth Rate in Feet	Maturity, Height in Feet	Wood Strength (Green) Lb. per Sq. In
Upright	Carolina poplar	2.67	80	5,300
	American elm	1.21	85	7,200
	Sycamore	1.07	75	6,500
	Silver maple	1.30	65	5,800
	Hickory	.93	65	11,000
	Norway spruce	1.50	60	Not available
	Lombardy poplar	1.50	60	Not available
Spreading	Sugar maple	.81	65	9,400
	Red oak	1.00	65	6,900
	White oak	.81	65	8,300
	Black walnut	.87	70	9,500
	Red maple	1.13	45	7,700
	Live oak	1.11	50	11,930
Horizontal	Norway maple	.72	50	Not available
	Black willow	1.67	50	3,800
	Box elder	1.33	40	Not available

*Approximate *normal* average rates in northern states, subject however to considerable variation due to soil, moisture and site conditions. As pruning stimulates growth, these values should be doubled to arrive at first year growth rate of topped trees.

serve as an interim guide until standard line clearance specifications for the industry may be developed, approved, published and distributed. Probably one year or more will be required for the committee to complete its work and submit a final report.

In view of this and the fact that the suggestions herewith listed cover most of the essential points to be observed by operating companies, we urge that copies of this information be made available to all engineers, line superintendents, general foremen, right of way men, tree trimming supervisors and foremen, and others who have any interest in line design and maintenance.

Design and Right-of-Way

Planning of overhead line structures to fit field conditions in advance of building is of *first importance* in providing and maintaining satisfactory tree and wire relations. Adequacy of tree clearance, economic cost of line maintenance and operation, reliable service and good public relations are largely *dependent* upon careful initial attention to the following items:

1. Keep constantly in mind that tree-free locations and deliberate tree avoidance, both where economically justifiable in establishing of new lines, aid maintenance and operation costs, safeguard service reliability and are a benefit in reducing tree density per average mile of an electric system.

2. Emphasize selection of tree-free right of ways in public places, also on private property, wherever permissible.

3. Develop and apply best economic balance between pole material costs and tree trimming costs, both construction and maintenance considered especially where conductors are above tree crowns.

4. Appraise in advance the degree of

EXHIBIT 2

Upright *Horizontal* *Spreading*

TREE FORM TYPES

line security from tree interference required and specify pole material and location to secure objective.

5. Recognize basic *tree form at maturity* as an important factor controlling pole heights and conductor position. (See Exhibits 1 and 2).

6. Design and install overhead secondaries, power and street lighting conductors to avoid central tree trunks and large limbs.

7. Recognize and allow for variation in annual growth rates between different tree species subject to local environmental effects of soil, moisture and climate. (See Exhibit 1.)

8. Apply wood strength knowledge of various tree species especially where conductors are under or at the side of tree crowns. (See Exhibit 1.)

9. In the northern and middle states, design new primary and transmission lines to provide at least two years' tree clearance between retrims.

Construction

1. Fully realize the significance of the fact that the original amount and quality of tree clearance as a rule definitely fixes the pattern for future retrims at each location.

2. Avoid topping of trees where clearance requirements will permit.

3. Install only poles of proper lengths to fit field conditions encountered. Great over-all benefits will accrue from careful observance of this point.

4. When installing primary or transmission lines near young immature trees, make allowance for future necessary growth enlargement of crowns.

5. Insist upon some separation of pole and tree alignments.

6. Where possible and permissible, alter crossarm and insulator arrangement to obtain greatest separation of conductors from trees.

7. To properly protect plant investment against early and rapid depreciation, trim trees as required to clear all electric conductors including services, secondaries, power and street lighting when initially installed.

8. Where permissible, remove all dead and weak trees which are a hazard to new transmission and primary distribution lines.

9. In the details of performing tree work during construction, observe all points listed under the *Operation Section* immediately following.

Operation

Along all electric lines which have been engineered and built for adequate tree clearances, initial trimming, also re-trimming for maintenance of essential operating conditions, resolves itself largely into an orderly routine application of *tree control* principles.

1. Retrim at regular intervals, preferably two years before new growth reaches primary lines and greater separation with transmission lines. This procedure provides greatest protective benefits and tends to maintain better tree condition.

2. Concentrate on weed tree removal and removal of other trees which are hazardous to electric service.

3. Make all cuts so as to leave no stubs.

4. Treat all wounds against the entrance of decay and insect infections.

5. In all trimming endeavour to preserve natural tree forms.

6. Where permissible, remove unsightly trees caused by previous improper line clearance work along electric lines.

7. Where trees have outgrown original pole heights or other line appurtenances, seek line alterations before retrimming.

8. Establish a standard minimum amount of clearance for each construction type and each tree species in any operating region and strive diligently to achieve a good degree of compliance therewith.

9. Carefully consider the possibilities of joint tree clearance operations with overhead line utilities located on the same poles or same side of public thoroughfare if equitable and workable arrangements can be made.

10. Cooperate and coordinate closely with agents of public authorities where line clearance work is located in public places.

11. Measure operating efficiency by *cost per meter* and average *cost per mile* of *pole line.*

General Policy

1. Adopt routine policy throughout engineering, construction and operating departments of *tree avoidance* where economically possible and for other reasons justifiable in overhead line work.

2. Recognize tree work for overhead line clearance as a separate branch of electric utility work.

3. Employ only trained tree workers as such procedure provides the most effective and economical results.

4. Employ professional foresters or the equivalent to supervise both construction and operating line clearance programs.

5. Authorize a policy of careful cooperation with public thoroughfare people and insist that it be applied in field details. An extension of this plan is to arrange conferences to discuss mutual problems with city, state and county street and highway departments. This or similar procedure should be helpful in some states.

6. Approve a workable plan of tree replacement for removals, to be applied with discretion by field forces.

7. In trimming trees for either construction or operating line clearance, always consult property owners for their wishes before starting tree work

unless previously and definitely arranged for.

8. A tree density survey through which any line clearance program may be definitely appraised and analyzed is recommended for those operating companies which are interested in definitely evaluing the scope of this operation.

9. Avoid cash payments for tree removal and trimming rights on public thoroughfares as such practice often reflects on constructive policy.

The major objectives toward which this subcommittee is working are enumerated as follows:

1. Reduction in over-all costs due to trees in the construction, operating and maintaining of overhead lines.
2. Encourage standardization of electric utility tree work for overhead line clearance.
3. Stimulate a greater degree of attention by the electric industry to tree preservation within permissible limits.
4. Electric utility education of the tree interference problem, and devise the most satisfactory solution.

We trust that the points herein enumerated under design, construction, operation and general policy for field application will aid materially in the major objectives sought.

L. L. Newman, New Orleans Public Service, Inc., New Orleans, Louisiana.

G. T. McCaskie, Public Service Electric & Gas Co., Newark, New Jersey.

M. T. Crawford, Puget Sound Power and Light Co., Seattle, Washington.

E. L. Handy, New York Power & Light Corp., Albany, New York.

G. D. Blair, Chairman, Consumers Power Co., Jackson, Michigan.

Effects of Electric Current on Man

By Charles F. Dalziel, Assistant Professor of Electrical Engineering, University of California, Berkley, and John B. Lagen, M.D., Assistant Professor of Medicine and Pharmacology, University of California Medical School, San Francisco, California

THE danger of exposure to electric shock has been increased by the widespread use of devices having exposed electrodes, such as the electric fence, the electric insect trap, the electric fly screen, and the electric cattle prod. Many of these devices are purchased and installed by persons who are not familiar with the principles involved or the dangers inherent in such apparatus. Because of the simplicity of construction, convenience, and economy afforded by the electric fence, many types are offered by small manufacturers or constructed by novices with little or no regard for safety. Some of the homemade varieties are energized directly from lighting circuits protected only by ordinary fuses. In others the current is limited to about 62.5 milliamperes with a 7½ watt incandescent light. More elaborate devices have been constructed using radio parts and

thermostatic interrupters. The authors recently tested one of these devices and found that the interrupter failed in the energized position when a resistor equivalent to the human body resistance was connected to the fence terminals. Many of these devices have proved unreliable or ineffective, and have caused numerous animal fatalities. Quite recently regulations governing some of these devices have been adopted, but the issue is far from being closed.

Several human deaths have been caused by contact with electric fences, and in the light of existing conditions it is indeed surprising that the number of fatalities has been so small. While some regulations have been adopted, the preparation of adequate regulations and the formation of safety codes have been impeded by lack of scientific information as to the amount of current that is safe for man. In the interest of public safety, it is essential that legislation be provided to permit only the sale and use of approved devices.* The public must be protected against the purchase of dangerous products.

An investigation of the energy requirements and safety of electric insect traps, undertaken by one of the authors in 1936, showed that no reliable information was available on currents required to control animals or to kill insects. Of much greater importance, there was little information available on the magnitude of electric currents safe for man. Therefore the original scope of the problem was expanded to include a study of the general effects of electric shock on man. This paper presents results obtained on direct current and 60-cycle alternating current.

A brief review of the effects of power-frequency currents on man may prove interesting and instructive. The threshold of perception is about one milliampere when electrodes are held in the hands. A very faint tingling sensation is first felt. This rapidly increases in intensity as the current is increased, and at the same time involuntary muscular contractions of the hand and wrist appear. These increase in intensity and progress up the arm to the chest with currents of 10 to 15 milliamperes. From 15 to 20 milliamperes the muscle contractions are severe and painful, and a sensation of mental discomfort difficult to describe may appear. At 20 milliamperes or higher, the chest muscles become involved, and breathing becomes somewhat difficult. Up to a certain point an individual can still release the electrified wire in spite of the involuntary muscular contractions. The authors have called the highest current at which muscular control is still possible the "let-go current".

The main object of our investigation was to determine the let-go currents of a large number of subjects. Of the 114 men tested on 60-cycle alternating current, the average let-go current was 15.5 milliamperes, and the highest was 21.6 milliamperes. In order to get an accurate determination, it was necessary to go above the let-go current of each individual. However, none of the subjects was given more than 2 or 3 milliamperes in excess of his value. What happens at values

*"Approved" means approved, labeled, or listed as conforming to the standards of the National Bureau of Standards, the Underwriters' Laboratories, Inc., the United States Bureau of Mines, or other similar institutions of recognized standing.

slightly above this is conjecture, at least as far as the authors are concerned. The subjects were exposed to the current for a matter of seconds only, just sufficient to give them time to exert a determined muscular effort. This exposure is distinctly in contrast with that of individuals who grasp an electrified wire and have to endure it until aid reaches them. The effects of fear must play an important role in these instances. The tetanic contraction of the chest muscles might be sufficient to interfere greatly with breathing, and after sufficient exhaustion from muscular effort, death might occur from asphyxiation. Currents in excess of those that cause involuntary cessation of breathing, due to effects on the muscles, are believed to result in temporary paralysis of the nerve centres which may paralyze the respiration for a considerable period of time even after interruption of the current. Somewhat higher currents cause ventricular fibrillation, which results in death due to failure of the heart muscle. The minimum current necessary to produce ventricular fibrillation in man has been estimated to be about 100 milliamperes for shock durations of three seconds or longer. Once the human heart muscles begin to fibrillate, little can be done to save the victim. Currents considerably in excess of this value cause violent contractions of the body musculature, and are believed to suspend the action of the heart, instead of causing it to fibrillate. The heart may resume its normal rhythm upon interruption of the current, or it may do so if resuscitation measures are applied promptly. Relatively large current (amperes, not milliamperes) produce sufficient heat to destroy nerves, muscle, and bone and to cause hemorrhages. Major damage to vital organs, especially that resulting from electric arcing, may be so severe that death is inevitable. Delayed death may be due to burns, hemorrhages, or other complications.

In many high-voltage accidents the combination of high contact resistances and severe muscular reactions results in limited currents of short duration. These may cause respiratory paralysis and cessation of breathing. The heart may continue to beat, it may fibrillate, or, which is more likely, it may come to a standstill. Thereupon unconsciousness and apparent death occur. However in many instances the victim may be saved. Since a layman cannot distinguish between these various possibilities, he should immediately give the victim artificial resuscitation. This should be continued until death is diagnosed by a physician, until rigor mortis sets in, until the body becomes cold, or until the victim revives. The value of the Schafer prone-pressure method of resuscitation must be emphasized, especially to men in the field. Nevertheless, the best means of reducing the present fatality rate of about one in 100,000 is instruction in the proper procedures for electrical workers, education of the public in the use of electrical equipment, and rigid adherence to safety codes. It is encouraging to note that only a very small percentage of the victims who recover from an electrical injury show any permanent disability.

Threshold of Perception

The threshold of perception was determined for direct current and com-

mercial 60-cycle alternating current. Each subject sat in a relaxed position in a chair with the palms of the hands resting on two number 7 copper-wire electrodes. The hands were moistened with a salt (sodium chloride) water solution in order to reduce contact resistance and permit the use of low voltages for safety. The current was gradually increased so that the subjects might become acquainted with the faint sensations of warmth and tingling. Repeated tests were then made to determine the smallest current that could be felt. The average of several trials was taken as the threshold value. The 60-cycle threshold current for 115 men was: 1.1 milliampere average, 0.4 milliampere minimum, 4.0 milliamperes maximum. The results are in close agreement with the generally accepted value of one milliampere. The threshold of perception for direct current for these 115 men was: 5.2 milliamperes average, 2.2 milliamperes minimum, 12.6 milliamperes maximum.

The tongue is probably the most sensitive organ likely to experience direct contact with a source of potential. In fact, a popular method of testing dry cells is to touch the battery terminals to the tip of the tongue. It was therefore considered of interest to determine the minimum current that is perceptible. Each subject sat relaxed in a chair and held two platinum test electrodes lightly on the tip of his tongue. The electrodes consisted of two number 18 wires one inch long and spaced one-half inch apart by means of a Bakelite separator. Platinum wires were used to minimize galvanic effects. The threshold value varied over a wide range among the subjects tested, and there was considerable variation in repeated tests on the same subject. As before, the threshold was taken as the average of several trials. The 60-cycle threshold for 115 men was: 43 microamperes average, 4.0 microamperes minimum, 315 microamperes maximum. The threshold for direct current for the 115 men was: 44 microamperes average, 0.6 microamperes minimum, 783 microamperes maximum.

Let-Go Currents

In these tests the subject grasped a test electrode consisting of a 12-inch length of number 6 copper wire. The circuit was completed by placing the other hand on a flat brass plate 8 inches in diameter. This permitted the subject to break the circuit at any time he desired, even though it was necessary for an observer to hold the hand flat to prevent it from curling. The current was gradually increased to accustom the subject to the sensations produced. After one or two trials, the current was increased at a moderate speed to a certain value, and at this point the subject was commanded to drop the test electrode. If he succeeded, the current was increased by steps until he was no longer able to let go of the wire; if he failed, the test was repeated at a lower value. The endpoint was checked by several trials, insufficient in number to cause fatigue, but sufficient to permit an accuracy within a range of about 0.5 milliampere.

Preliminary tests indicated that it was immaterial whether the other hand or one of the feet was placed on the indifferent electrode. They also indi-

cated that the let-go current was unaffected by the surface condition of the hands, tests having been made with dry hands and hands moist from perspiration, salt, and weak acid water solutions. The standard procedure was to keep the subject's hand moistened with a weak salt solution during the tests. This was done in order to secure more uniform conditions, to lower contact resistances, and particularly to lessen unpleasant sensations at localized tender spots due to high current densities. As the salt solution dried on the hands, the voltage and resistance increased, although the let-go current remained substantially the same. It had previously been found by tests with open-circuit voltages from 5 to 9,720 volts that sensations and muscular reactions were proportional to the current and not the voltage. These two findings confirm the generally accepted opinion that current and not voltage is the proper criterion of shock intensity.

The let-go currents for 114 men were: 15.5 milliamperes average, 9.7 milliamperes minimum, 21.6 milliamperes maximum. As would be expected, the let-go current was higher for the huskier better-muscled subjects than for the thin, slight or lighter subjects. Right-handed men grasped the test electrode with the right hand, and left-handed individuals with the left. In the few trials that were made, the other or weaker hand had a limit of about 0.5 milliampere less than the test hand in the same subject.

Let-go tests were also conducted with direct current. Steady direct currents produced a sensation of internal heating of the hands and arms with only slight muscular contraction, although severe muscular contractions were produced by sudden changes in current magnitudes, and a severe shock was experienced each time the circuit was broken. Many subjects stated they would almost rather maintain contact in spite of the burning sensation than experience the shock produced when they released the wire. The values obtained in the tests were the maximum currents released and represent the limit of endurance rather than the let-go value. The limits of endurance for 28 men were: 74 milliamperes average, 61 milliamperes minimum, 83 milliamperes maximum.

Safe Electric Current for Man

Several factors must be considered in deciding what constitutes a safe current for man. The victim of an accidental shock can often release himself by using muscles little affected by the current. The muscular reactions produced by the current may tend to break the circuit rather than to improve it, or loss of balance may free the victim. However, it is doubtful if any of these methods would be of avail when contact is established by gripping an electrified wire so that the path of the current is across the body. Naturally, when a man realizes his dangerous predicament, he will exert more effort to free himself than that stimulated in these experiments. Fright, however, might tend to nullify his efforts, and exhaustion certainly would. It was therefore concluded that the safe electric current for man is that value which can be released by using muscles directly affected by the current.

The maximum current considered safe for man has been determined from

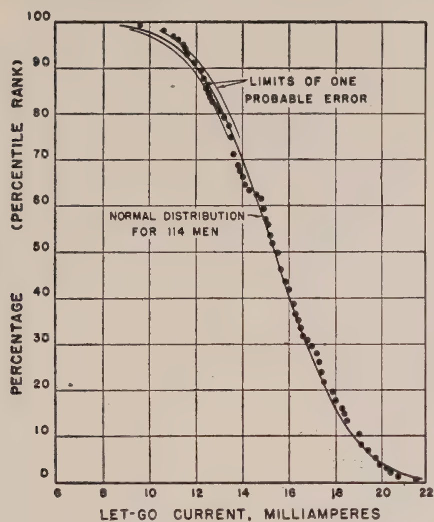


Fig. 1—Distribution curve, 60-cycle let-go current.

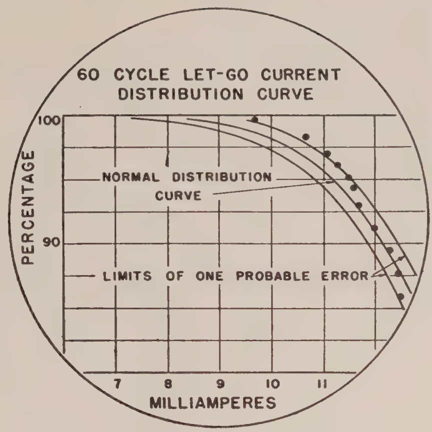


Fig. 2—A magnified section of figure 1.

a statistical study of the experimental results. The curves of figure 1 show some of the results graphically. Obviously, the farther to the left one goes on the curve, the greater are the number of men who can release a given current. The conclusions are as follows. If it is assumed that the 114 men used in this experiment represent a cross section of all men of the same age and physical condition, then one man in 200 would not be able to let go of 8.8+or−0.8 milliamperes or more current. This figure is based on a very conservative analysis. Having taken into consideration the factors mentioned, the authors are of the opinion that a reasonably safe 60-cycle alternating current for man is 8 to 9 milliamperes.

Steady direct currents produced much less severe muscular contractions than those produced by alternating currents. Within the range covered in these experiments, the physical endurance and will power of the subject fix the limit of the maximum release currents. Considering the factors, it appears conservative to conclude the maximum safe direct current for man to be at least 80 milliamperes.

For women and children the safe values for direct current and for 60-cycle alternating current may well be less, and in the interest of safety, no figures should be stated until adequate investigations have been made.—*Electrical Engineering.*

The Use of Electrical Appliances in Ontario

SUBMITTED herewith are tables showing the results of surveys made in Hydro municipalities and in Hydro rural power districts and giving the estimated number of electrical appliances in use by urban and rural consumers at the end of 1940, as follows:

Table No. 1—Estimated number and per cent of saturation of major electrical appliances in use by domestic consumers in urban municipalities.

Table No. 2—Comparison by systems of saturation of major electrical appliances in use by domestic consumers in urban municipalities.

Table No. 3—Estimated number and per cent of saturation by systems of major electrical appliances in use among hamlet consumers in rural power districts.

Table No. 4—Estimated number and per cent of saturation by systems of major electrical appliances in use among farm rural consumers.

Table No. 5—Comparison of per cent of saturation of appliances in use in homes of urban and rural consumers.

Each year all Hydro municipalities and rural power districts are asked to submit a report showing the number of appliances in use. Reports were not received from a small percentage of the municipalities and rural districts. The attached estimates were compiled based on the reports received.

Table No. 1 shows that in some cases saturation of appliances in municipalities leaves considerable opportunity for educational and promotional activities, such as ranges, water heaters and refrigerators.

Table No. 2 indicates the difference in saturation points of the various appliances in different parts of the province. For example, ranges in Georgian Bay system have a saturation of 20.7 per

TABLE No. 1

TABLE SHOWING ESTIMATED NUMBER OF MAJOR ELECTRICAL APPLIANCES IN USE AMONG DOMESTIC CONSUMERS AT END OF 1940 IN URBAN MUNICIPALITIES

Appliances	Number	Saturation
Electric		%
Ranges	173,207	30.9
Hot plates	101,356	18.1
Washers	276,516	49.3
Vacuum cleaners	190,082	33.9
Water heaters (flat rate)	65,357	11.6
Water heaters (metered)	61,582	11.0
Grates	41,078	7.3
Air heaters	166,037	29.6
Ironing machines	17,552	3.1
Irons	516,804	92.2
Refrigerators	119,757	21.3
Toasters	349,132	62.3
Grills	59,211	10.5
Furnace blowers and oil burners	36,075	6.4
Air conditioners	7.057	1.2
Radios	456,323	81.4
Number of Consumers	560,452	

Corrections

To be inserted in the June, 1941 issue, page 189.

TABLE No. 2

TABLE SHOWING COMPARISON OF SATURATION OF MAJOR ELECTRICAL APPLIANCES IN USE BY DOMESTIC CONSUMERS IN URBAN MUNICIPALITIES AT END OF 1940 IN EACH SYSTEM

Appliances	All Systems	Niagara System	Georgian Bay System	Eastern System	Northern Systems
Electric					
Ranges	30.9	30.2	20.7	35.7	41.0
Hot plates	18.1	15.4	34.8	22.2	36.0
Washers	49.3	51.0	47.0	41.5	43.1
Vacuum cleaners	33.9	36.4	21.3	24.2	30.7
Water heaters (flat rate)	11.6	12.1	5.9	11.2	11.9
Water heaters (metered)	11.0	9.7	8.0	17.9	18.4
Grates	7.3	8.3	1.6	4.5	3.8
Air heaters	29.6	31.1	15.4	27.5	24.8
Ironing machines	3.1	3.4	1.8	2.3	1.9
Irons	92.2	92.4	86.4	91.1	97.7
Refrigerators	21.3	23.1	15.3	15.4	13.3
Toasters	62.3	61.5	60.6	64.8	70.8
Grills	10.5	8.1	10.6	20.4	27.4
Furnace blowers and oil burners	6.4	6.9	3.9	5.7	2.3
Air conditioners	1.2	1.2	0.5	1.5	1.6
Radios	81.4	81.9	78.3	78.2	85.3

cent while the Eastern Ontario system is 35.7 per cent. However, refrigerators and radios are almost equal in the two systems.

Table No. 5 gives a comparison of the saturation of appliances in the homes of urban, hamlet and farm consumers. Hamlet and farm saturation is low in each item shown. Their buying power, no doubt, is small, but also educational and sales efforts have not reached these consumers as they have similar consumers in the cities and towns.

The growth in use of appliances by rural hamlet consumers has barely kept pace with the growth in the number of consumers and would indicate a considerable field for sales effort.

The growth in use among rural farm consumers, like the hamlet consumers, has barely kept pace with the growth in the number of consumers.

The estimated number of appliances in use each year among urban domestic consumers, since 1924, shows the growth has been gradual and, except

TABLE No. 3

Showing estimated number of major Electrical Appliances in use among Hamlet Consumers in Rural Power Districts at end of 1940 by Systems

	All Systems		Niagara System		Georgian Bay and Northern System		Eastern Ontario System	
	No. of Appliances	Per cent of Saturation	No. of Appliances	Per cent of Saturation	No. of Appliances	Per cent of Saturation	No. of Appliances	Per cent of Saturation
In The Barn:								
Electric								
Motors	2,009	3.9	1,354	4.5	197	2.3	458	3.8
Pumps	691	1.4	489	1.6	106	1.3	96	0.8
Grain grinders	19	......	13	......	....	......	6	0.1
Milking machines	6	......	....	......	....	......	6	0.1
Milk coolers	14	......	12	......	....	......	2	.....
Cream separators	61	0.1	5	......	3	......	53	0.4
Churns	9	......	4	......	1	......	4	.....
Incubators	97	0.2	82	0.3	2	......	13	0.1
Brooders	123	0.2	93	0.3	5	0.1	25	0.2
Hot beds	7	......	4	......	1	......	2	.....
Water heaters (flat rate)	5	......	....	......	5	0.1	....	.....
Water heaters (metered)	3	......	....	......	1	......	2	.....
Miscellaneous	394	0.8	302	1.0	39	0.5	53	0.4
In The Home:								
Electric								
Ranges	6,697	13.2	4,733	15.6	776	9.2	1,188	9.8
Hot plates	12,929	25.4	6,478	21.3	3,076	36.5	3,375	27.9
Washers	24,253	47.6	15,575	51.2	3,244	38.5	5,434	44.9
Vacuum cleaners	8,618	16.9	5,881	19.3	920	10.9	1,817	15.0
Water heaters (flat rate)	2,063	4.1	1,601	5.3	135	1.6	327	2.7
Water heaters (metered)	1,081	2.1	927	3.1	81	1.0	73	0.6
Grates	433	0.9	249	0.8	58	0.7	126	1.0
Air heaters	3,700	7.3	2,295	7.6	333	4.0	1,072	8.9
Ironers	817	1.6	495	1.6	151	1.8	171	1.4
Hand irons	39,607	77.8	23,668	77.9	6,233	74.0	9,706	80.1
Refrigerators	8,661	17.0	5,425	17.8	1,231	14.6	2,005	16.6
Toasters	27,576	54.1	16,012	52.7	4,388	52.1	7,176	59.3
Radios	37,675	74.0	22,894	75.3	5,199	68.8	9,582	79.1
Furnace blowers	1,024	2.0	739	2.4	50	0.6	235	1.9
Pumps	6,288	12.3	4,032	13.3	771	9.2	1,485	12.3
Miscellaneous	1,839	3.6	1,469	4.8	150	1.8	220	1.8

TABLE No. 4

SHOWING ESTIMATED NUMBER OF MAJOR ELECTRICAL APPLIANCES IN USE AMONG FARM CONSUMERS IN RURAL POWER DISTRICTS AT END OF 1940 BY SYSTEMS

	All Systems		Niagara System		Georgian Bay and Northern System		Eastern Ontario System	
	No. of Appliances	Per cent of Saturation	No. of Appliances	Per cent of Saturation	No. of Appliances	Per cent of Saturation	No. of Appliances	Per cent of Saturation
IN THE BARN:								
Electric								
Motors	8,754	14.9	6,121	15.1	923	13.4	1,710	15.1
Pumps	8,170	13.9	6,789	16.8	491	7.1	890	7.9
Grain grinder	3,426	5.8	2,430	6.0	578	8.4	418	7.4
Milking machine	2,041	3.5	1,298	3.2	118	1.7	625	5.5
Milk cooler	1,280	2.2	992	2.5	63	0.9	225	2.0
Cream separator	3,946	6.7	2,435	6.0	397	5.7	1,114	10.1
Churn	616	1.1	408	1.0	45	0.7	163	1.4
Incubators	706	1.2	486	1.2	61	0.9	159	1.4
Brooders	901	1.5	663	1.6	55	0.8	183	1.6
Hot beds	59	0.1	44	0.1	7	0.1	8	0.1
Water heater (flat rate)	146	0.3	127	0.3	11	0.2	8	0.1
Water heater (metered)	69	0.1	41	0.1	10	0.1	18	0.2
Miscellaneous	577	1.0	435	1.1	78	1.1	64	0.6
IN THE HOME:								
Electric								
Range	10,539	17.9	9,362	23.1	343	5.0	834	7.4
Hot plates	12,581	21.4	8,951	22.1	1,395	20.2	2,235	19.8
Washers	34,821	59.3	25,804	63.7	3,259	47.2	5,758	51.0
Vacuum cleaner	9,468	16.1	7,707	19.0	511	7.4	1,250	11.1
Water heater (flat rate)	2,647	4.5	2,477	6.1	31	0.5	139	1.2
Water heater (metered)	1,283	2.2	1,137	2.8	56	0.9	90	0.8
Grates	629	1.1	541	1.3	20	0.3	68	0.6
Air heater	4,626	7.9	3,758	9.3	179	2.6	689	6.1
Ironers	824	1.4	628	1.6	57	0.8	139	1.2
Hand irons	44,775	76.3	32,839	81.1	4,466	64.6	7,470	66.1
Refrigerators	9,206	15.7	7,186	17.8	489	7.1	1,531	13.5
Toasters	31,036	52.9	23,255	57.4	2,660	38.5	5,121	45.3
Radios	44,269	75.4	31,696	78.3	4,681	67.8	7,892	69.8
Furnace blowers	1,209	2.1	928	2.3	52	0.8	229	2.0
Pumps	9,415	16.0	7,503	18.5	650	9.4	1,262	11.2
Miscellaneous	1,822	3.1	1,703	4.2	53	0.8	66	0.6

TABLE No. 5

COMPARISON OF APPLIANCES IN USE IN HOMES OF URBAN AND RURAL CONSUMERS AT END OF 1940

Appliances	Urban % of Saturation	R.P.D. Hamlet % of Saturation	R.P.D. Farm % of Saturation
Electric			
Ranges	30.9	13.15	17.95
Hot plates	18.1	25.38	21.43
Washing machines	49.3	47.61	59.32
Vacuum cleaners	33.9	16.92	16.13
Water heaters (flat rate)	11.6	4.05	4.51
Water heaters (metered)	11.0	2.12	2.18
Grates	7.3	0.85	1.07
Air heaters	29.6	7.26	7.88
Ironing machines	3.1	1.60	1.4
Irons	92.2	77.76	76.27
Refrigerators	21.3	17.00	15.68
Toasters	62.3	54.14	52.87
Furnace blowers and burners	6.4	2.01	2.06
Radios	81.4	73.97	75.41

for ranges, was only slightly affected by boom and depression years.

The average consumption in urban homes of Ontario is slightly over 2,000 kilowatt-hours per year. It is estimated that an average home could easily consume 10,000 kilowatt-hours per year. Many small homes are consuming more than this. It is, therefore, possible to increase the average consumption four to five times by the greater use of electrical appliances. The absence of waterworks systems in smaller municipalities curtails the use of water heaters. Natural gas and municipal gas plants affect the use of both water heaters and ranges.

Notwithstanding these and other deterrents, we are still far from the saturation point for many electrical appliances throughout the Province.

W. R. SIBLEY, Parkhill

In the sudden death of W. R. Sibley on Monday, June 2, 1941, Parkhill lost one of its best known and highly esteemed citizens. He was attending to his office duties on that morning when he was seized with an attack, shortly after which he passed away.

He was born near Stouffville, Ontario, in 1873. Over forty years ago he went to Parkhill, where he conducted a photograph studio, and carried on business as a house decorator.

When Parkhill began taking power from The Hydro-Electric Power Commission of Ontario, early in 1920, he was appointed secretary-treasurer of the local Hydro-Electric System. In addition to performing his office duties, he also did the meter reading, and in making his rounds of the houses, his quiet friendliness endeared him to everyone. The healthy condition of the Parkhill utility is testimony of the excellence of his guiding hand.

New Concrete Specifications

(Continued from May.)

15. Ready-Mixed Concrete

(a) *General*

Ready-mixed concrete may be used on the work subject to the following special conditions. In all other respects, both it and the material from which it is made shall comply fully with the requirements of these specifications.

(b) *Mixing*

The concrete shall be mixed in an approved truck drum mixer. The mixing equipment shall be capable of combining the aggregate, cement, and water within the specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation. Each batch of concrete shall be mixed not less than 50 nor more than 150 revolutions of the mixer at the rate of rotation specified by the Manufacturer as mixing speed. The volume of the mixed materials in the mixer-drum shall not exceed the manufacturers' rated capacity of the mixer. Additional mixing, if any, shall be done at a slower speed for agitation and shall be in accordance with the Standards adopted by the Mixer Manufacturers' Bureau of the Associated General Contractors of America. The drum shall be water-tight when closed.

The truck mixer shall be equipped with a tank for carrying the mixing water, and the water shall be measured and added to the tank at the proportioning plant.

(c) *Time of Hauling*

Unless the Engineer permits a longer period, concrete shall be delivered and discharged from the mixer within one hour after the introduction of the mixing water to the dry materials.

(d) *Determination of Volume of Concrete*

Where ready-mixed concrete is purchased by the Commission, the basis of measurement of the concrete shall be the cubic yard; and the volume of concrete delivered shall be taken as equal to the sum of the absolute volumes of its separate ingredients, as calculated from the weight of each material and its specific gravity. Proper correction shall be made in this calculation for free and absorbed moisture contained in the aggregate.

16. Cold Weather Requirements

(a) *Temperature of Concrete*

Concrete delivered when outdoor temperatures are lower than 40 deg. fahr. shall arrive at the work having a temperature not less than 50 deg. fahr., nor greater than 90 deg. fahr., unless otherwise specified by the Engineer.

If, at any time in the progress of the work, the temperature is, or in the opinion of the Engineer will, within twenty-four hours, drop to 40 deg. fahr., or below, the water and aggregate shall be heated.

17. Construction and Setting of Forms

(a) *Materials*

All material used in forms shall be approved. Lumber shall be sound, straight, free from warp, decay, loose knots; of sufficient size and strength; and dressed smooth, sized to width and thickness. Material once used in forms shall be culled, have nails withdrawn,

and surfaces to be in contact with concrete thoroughly cleaned before being used again.

(b) *Design and Strength*

All forms shall conform to the shapes, lines and dimensions of the concrete as indicated on the drawings; shall be substantial, rigid, and unyielding; so designed, tied, and supported that they will not deflect or bulge under the weight or pressure of the newly placed concrete, or of superimposed loads; and tight enough to hold mortar.

(c) *Internal Ties*

Bolts and rods shall be used for internal ties, so arranged, that when the forms are removed, no metal shall be within one inch of any surface. Wire ties shall not be used on any portion of the work unless written permission is given by the Engineer.

18. TRANSPORTING AND DEPOSITING CONCRETE

(a) *Transporting Concrete*

Concrete shall be conveyed from the mixer to the place of final deposit by methods which will prevent the separation or loss of materials. Equipment for conveying concrete such as buckets, cars and trucks, bolt conveyors, pneumatic, and pumping shall be of such size, design and condition as to insure a practically continuous flow of concrete at the delivery end without separation of the materials. All methods used shall be authorized by the Engineer.

(b) *Chuting*

The use of chutes to convey concrete will not be permitted except that short lengths of chutes less than 10 feet in total length may be used immediately adjacent to or in the forms. Where chutes are used they shall be so constructed and arranged as to permit continuous flow of the concrete without separation of the ingredients. All chutes or equipment used shall be as close as possible to the point of deposit and shall be so arranged that the free fall of the concrete shall not be greater than five feet.

The dropping of concrete through flexible elephant trunk drop chutes will be permitted providing some means is used at the lower end to retard the speed of the falling concrete and prevent it from segregating by falling on a hard surface.

(c) *Pumpcrete Machines*

Where concrete is transported by pressure through a pipe all trestles or scaffolding supporting the pipe shall be erected independent of the forms.

(d) *Depositing*

Concrete shall be deposited as nearly as possible in its final position to avoid rehandling. Concreting shall be carried on as a continuous operation until the unit of operation is complete and by methods which shall prevent separation or loss of ingredients.

(e) *Placing Concrete Under Water*

When it is necessary to place concrete under water a tremie, a watertight box or bucket which is discharged from the bottom after it has contacted the foundation or surface of the concrete, shall be used when approved by the Engineer.

(f) *Cleaning Equipment*

The inner surfaces of the mixing and conveying equipment used on the work shall be kept free from hardened concrete and foreign materials. Transporting equipment shall be cleaned at frequency intervals. All equipment

shall be thoroughly flushed with water after each run. The water used for this purpose shall be discharged outside the forms.

19. Compacting

(a) *General*

All methods of compaction shall be approved by the Engineer. As concrete is being placed it shall be compacted thoroughly and uniformly by means of tramping, hand-tools, vibrators, or finishing machines in order to secure a dense structure, close bond with reinforcement, and smooth surfaces. The concrete shall be worked well around the reinforcing and embedded fixtures, and into the corners of the forms. Concrete shall not be worked more than necessary to consolidate it as overwork causes it to segregate and moves water and fine particles to the surface.

(b) *Vibration*

Heavy duty internal vibrators, powered by compressed air or electricity, of a type, size, capacity and frequency approved by the Engineer shall be available on the job, in good condition, before concreting is started and shall be used as and when directed by the Engineer. For reinforced concrete or in restricted forms, flexible operating handles will be required; for mass concrete the motor and case shall be directly attached to a vibrating element of considerable weight.

A vibration frequency of about 7000 is considered most effective and frequencies of at least 5000 are desirable. Application of the vibrators shall be made systematically and at such intervals that the zones of influence overlap. The vibrator shall be applied at any point only for such a period that the concrete is properly compacted and not for such a time that segregation will occur.

20. Method and Rate of Depositing

Concrete shall be deposited continuously and as rapidly as practicable until the structure is completed or until satisfactory construction joints can be made, as called for on the plans or otherwise directed by the Engineer. The rate of depositing shall be not greater than five feet per hour in height and shall not be dumped in the form faster than the placing crew can compact it properly. At least two hours must elapse after depositing concrete in the columns or slabs before depositing in beams, girders or slabs supported thereon. Continuous placing of concrete to heights of 65 to 70 feet will be permitted.

The concrete shall be deposited in horizontal layers in the forms as nearly as possible in its final position to avoid rehandling; it shall be so deposited as to maintain, until completion of the unit, a plastic surface approximately horizontal. The piling up of concrete in the forms in such a manner as to permit mortar to escape from the coarse aggregate will not be permitted.

21. Dry Pack Grouting

The volumetric proportions for dry-pack grouting shall be one part of cement to two and one-half parts of concrete sand passing through a fly-screen (sieve No. 16). Only sufficient water shall be added so that it will pack when placed under pressure. The total water added to the dry material shall not be greater than one and three-quarter gallons per sack of

cement. Curing of the concrete shall conform to the requirements of Sections 23 and 24 of this Specification.

22. Construction Joints

Horizontal construction joints will not be permitted unless called for on the plans and then shall be made so that the face joint will be level and in a straight neat line.

Vertical construction joints shall be built in strict accordance with the plans.

When called for on the plan, vertical construction joints on wall sections shall have a "V" groove on the sides and top. The side joints shall be made as shown on the drawing and the top joint by an edging tool which shall produce a groove one inch in depth.

23. Curing and Protection

All freshly placed concrete surfaces shall be protected from the elements and from defacement due to building operations. The Contractor shall provide, and use when necessary, enough tarpaulin or other suitable material to cover completely or enclose all freshly finished concrete.

As soon as the concrete has hardened sufficiently to prevent damage thereby, provision shall be made for maintaining the concrete in a moist condition or by approved methods for a period of at least ten days after the placement of the concrete. For high early-strength concretes, special moist curing shall be provided for at least the first three days of the ten-day period after the placement of the concrete. Horizontal surfaces shall be covered with at least one inch of wet sand or other approved moisture-retaining covering. Intermittent drying shall not be permitted.

24. Precautions in Freezing Weather

Mixing and placing concrete during freezing weather shall only be done with the approval of and as directed by the Engineer. Suitable means shall be provided for maintaining all parts of the concrete at a temperature of at least 50 deg. fahr., for not less than seventy-two hours after placing, or until the concrete has thoroughly hardened. The methods of heating the materials and protecting the concrete shall be approved by the Engineer, and shall be such as will prevent local drying. Salt, chemicals, or other foreign materials shall not be mixed with the concrete for the purpose of preventing freezing.

25. Inspection

Adequate facilities shall be provided the Engineer to enable him to inspect all processes and equipment, and to inspect and sample all materials used in the manufacture of the concrete delivered under this specification.

26. Samples of Concrete

Samples of concrete taken for the purpose of determining whether or not the concrete meets the requirements of this specification shall be secured at the point of delivery during the discharge of the batch. Samples shall consist of not less than one cubic foot obtained at not less than three points in a batch.

27. Concrete Tests

(a) *Testing Facilities*

The contractor shall supply, if required, and to the satisfaction of the Engineer, a suitable building for field laboratory equipped with tables, benches, power and water supply, drainage and heat, and moist room for stor-

age of concrete cylinders. This storage shall keep the concrete cylinders moist at a temperature of 70 deg. fahr., plus or minus 5 deg. fahr., summer and winter. Heat control equipment and all testing apparatus will be provided and installed by the Commission.

(b) *Test Cylinders*

The following table shows the number of tests to be taken during concreting operations:

Total Cu. Yds. of Concrete placed during day	Number of Strength Tests to be Taken
1 to 100	1 test for each 100 cu. yd.
101 to 1000	1 " " " 300 " "
1001 to 2000	1 " " " 500 " "

Three cylinders shall be considered a test.

28. Form Removal and Concrete Patching

(a) *Removal of Forms*

Forms shall not be removed until the concrete has thoroughly hardened and is of sufficient strength to safely carry its own weight together with construction loads likely to come upon it and until permitted by the Engineer.

(b) *Voids and Stone Pockets*

All voids, stone pockets, fins and dents discovered after the removal of the forms shall not be filled or pointed up until viewed and until instructions are given by the Engineer. Before repairing voids, etc., all loose concrete shall be removed and the surface shall be roughened, keyed and well-soaked with water. In replacing the concrete or mortar, the color shall match the surrounding concrete and be allowed to set before rubbing.

29. Finished Surfaces

(a) *Horizontal Surface Finishes*

All concrete or mortar wearing surface shall be placed as a monolith except where instructions are otherwise given by the Engineer.

Surfaces shall be drained of free water when nearing the finish elevation. Where possible the concrete at the top of the lift shall be dried up by reducing the water content to approximately four gallons per sack of cement.

Surfaces shall be finished by one or more of the three operations of screeding, floating or trowelling. Screeding shall consist of moving a straightedge or template with a saw motion along wood or metal strips established as guides. This shall be done immediately after compaction to give the surface its approximate shape and elevation.

Floating shall consist of working the surface with a wood float. It shall be commenced shortly after the surface is struck off or screeded. The operation shall be done sparingly at first as excessive working at this time tends to bring an excess of fines and water to the surface. In order to obtain a good finish, the final floating shall be done when the concrete has reached the proper stage in the setting process. When an extremely smooth or dense surface is required, the floating shall be followed by finishing with a steel trowel when the surface can no longer be dented with the finger.

(b) *Mortar Applied to Set or Fresh Concrete*

For bonded topping it is essential that the surface of the concrete base shall be thoroughly cleaned and sufficiently rough to provide good bond. Before the base has fully hardened, all laitance, scum, loose aggregate, and dirt shall be removed with a stiff

broom or by an application of air pressure and water, so as to leave the coarse aggregate slightly exposed. In order to minimize differential volume changes between topping and base, the surface of the base shall be kept thoroughly moist for at least 24 hours prior to placing the finish, but no free water shall be applied or allowed to remain on the surface within 30 minutes of the time when the finish is to be placed.

(c) *Proportions for Topping Mortar*

Where a surface mortar is to be placed on new or hardened concrete, the proportions by volume shall be one part of Portland cement, two parts of concrete aggregate, which shall pass through fly-screen (sieve No. 16). Not over 3½ gallons of water per sack of cement shall be used.

(d) *Time of Mixing for Topping Mortar*

All wearing surface mortar shall be mixed for not less than five minutes after all ingredients including the water are in the mixer.

(e) *Preshrunk Surface Mortars*

Where the wearing surface is to be placed on hardened concrete the mortar shall have been mixed ½ to 1 hour before being placed.

(f) *Placing, Compacting, Screeding and Finishing*

After the base has been properly prepared and screeds are in place, a thin coat of neat cement paste shall be broomed into the surface of the concrete base for a short distance ahead of the topping. The wearing surface shall be evenly spread, tamped and brought accurately to grade with a straight edge, and finished as previously described.

(g) *Rubbed Surfaces*

Soon after the face forms have been removed all fins or other projections shall be carefully removed and where patching is necessary the instructions given under Section 28 of this Specification shall be followed.

The surface to be finished shall be wetted and rubbed with a carborundum brick, or other abrasive, without applying any cement or other coating, until even and smooth. When this has been done, the grout or mulch which has collected shall be thoroughly washed off. For surfaces not specified to be painted, the surface shall again be wetted and rubbed until a small accumulation of fine grained paste is produced. This paste shall not be removed but shall be carefully spread with a moist Kalsomine brush, burlap or other approved means to form a uniform, very thin coating upon the surface of the concrete.

Corrections

In the May issue, page 157, last line, the temperature should have been given as "about 70 deg. fahr." Also on page 151 of the same issue, in the paragraph listing systems in order of system peak loads, that in third place should have been stated as "Commonwealth Edison Company and subsidiaries."

Alternating Current 50 Years Ago

A RECENT issue of *The Electrical Times* contains some some notes by C. S. Vesey Brown, who began working with Ferranti in August, 1887, at the Grosvenor Gallery Electric Lighting Works in London, England, "then in its transition stage from a privately owned local concern, buried in a cellar, to a full blooded electric power station, with Parliamentary powers extending from Deptford to Chelsea and with ambitious projects to supply power and light from an 83 cycle single phase circuit." The duties apportioned to the staff of which Ferranti was chief "were roughly, generation and control of the engine room, distribution by overhead cables, installation of transformers (2,500/100 volt), and preparation of meters (mercury bath Ferranti type)."

After naming a number of men who got their early training there and later became known in other parts the author states in part:—Before these various pioneers, devoted to their Chief's service, could develop his ideas, they each had to learn what he wanted to be at. "Start right from the beginning" was the order of the day, and "learn by practical experience" the cause and effect of each operation. Not for them a catalogue to choose from—there were none—and nowhere could be found a list of standards. Cable-makers, electrical apparatus, accessories, dynamo and motor builders themselves rarely knew what to expect from their designs. If a cable did not heat up on passing a certain current density, then "shove a bit more through and chance it". If switches supplied from a continental maker did not spark when opening the circuit, then rate them 100 volts or 10 amperes more and, again chance it. If a dynamo was designed to give 20 amperes at 200 volts running at 2,000 rev. per min., and another 10 amperes or 50 volts was wanted to supply some urgent need, then run it at 3,000 rev. per min. and, again, "chance it".

The founders of the London Electric Supply Corporation promoted an exhibition held on May 13, 1888, at the Grosvenor Gallery for the benefit of Mr. Joseph Chamberlain, . . . to show what electric supply at 10,000 volts could do. One hundred 20-c.p. incandescent lamps, each consuming approximately 70 watts, were strung up in series, on silk strings to insulate the circuit, and lighted up from a 4-to-1 transformer off the 2,500 volt local supply. He said that it was an astonishing thing to see 10 h.p. transmitted through such a thin wire.

Ferranti's associates took up an option to erect a hydro-electric power station on the Niagara Falls (Canadian side) and interested capitalists in Canada joined them. One of these a well-known polish *émigré*, who had established ironworks in Canada, came over to London to see for himself what was being done. Ferranti, without further ado than giving orders, arranged to run the Grosvenor generators as motors off the Deptford generators.

One Sunday morning, when all good people were supposed to be asleep and not in want of electric light, connections were made so that the Grosvenor

was run off Deptford for this gentleman's edification.

In the early days of the development of the Grosvenor, and to secure consumers, a retired naval officer was engaged to interview and canvas private houses in the so-called aristocratic areas covered by the Company's power of supply. Armed with all sorts of arguments as to the advantages of using electric light in the preservation of valuable pictures or other *objets d'art* to displace the injurious gas jet—flat burners belching out huge volumes of sulphurous fumes, as, so far, the Welsbach incandescent mantle had not been invented—he was sent forth on his mission. He soon came back with the news that no one had yet reached the use of gas and at every one of the houses he called on they were users of best paraffin wax candles.

One of the difficulties of the organization was to obtain trained staff. Engine drivers came from the railways. Firemen came from marine service, mostly merchant, but occasionally from the Navy. . . . what would have happened to Deptford if it had been "thrown to the wolves" in the "dark days" of the 1890's, when disaster after disaster fell on the luckless Grosvenor-Deptford electric lighting scheme? How the d.c. men chuckled, how St. James and Pall Mall, Westminster, Chelsea, Notting Hill, "Crompton's Company"—as we called the Kensington and Knights bridge—amongst others added to their already long list of satisfied consumers and how one organ of the technical press seized on every opportunity to show how the "Ferranti" alternating current system was doomed. Even the writer's old friend and ally, the late Lord Kelvin, wrote to him to say that h.t.d.c. transmission seemed to him to be more efficient and less likely to give trouble than h.t.a.c. at 10,000-11,000.

Up to that time there was nothing in the way of switchgear design to resist high tension, or possible fire from excessive sparking—then little understood in the case of a.c. circuits. Then, also, we used ebonite handles with metal strips fastened by simple screws or studs, connecting bent strips of copper soldered to rubber covered cables. These led to transformer terminals fastened in with sulphur insulating solution considered sufficient for a good job. Ferranti then went into the matter and the writer assisted him in the first designs made for this purpose at his house in Hamstead. Switchgear from these designs is in use in the Trafalgar Square substation today . . . Not bad for 50 years . . .

THE BULLETIN

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The Thirty-third Annual Report

THE Thirty-third Annual Report of The Hydro-Electric Power Commission of Ontario has just been released and distributed to the co-operating municipalities.

In addition to the financial statements of the Commission as called for by the Power Commission Act, the Annual Report contains balance sheets and operating reports of more than 290 Hydro utilities, owned by the co-operating urban municipalities. Townships and the smaller villages are served by the Commission through 184 rural power districts.

Although in view of war conditions the size of the Annual Report has been reduced by the elimination of certain interesting but not essential material, the valuable continuing statistical records of progress which form the largest section of the Report have been retained.

Dr. T. H. Hogg, Chairman and Chief Engineer, in the Introduction to the Report states that the past year's work of The Hydro-Electric Power Commission of Ontario has been dominated by the necessity of co-ordinating its activities to the war effort of Ontario and the Dominion, so that for the war industries of Ontario there should be ample supplies of power available wherever and whenever needed. A greatly increased demand for power for industries manufacturing munitions and war supplies was met without undue difficulty.

The collapse of France made it necessary to accelerate greatly the pace of Canada's war effort and this stimulated demands for power. It became evident also that the Commission would have to advance its programme for additional supplies for the future and several plans were put into operation.

Under war conditions the Commission must plan for increased energy requirements in greater proportion than for increased demand. Not only must generating capacity be ample, but there must be sufficient additional water stored or available to keep this capacity working for longer hours. In this connection Dr. Hogg points out that the arrangements made in friendly co-operation with the United States in con-

CONTENTS

Vol. XXVIII No. 7
JULY, 1941

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

nection with the Ogoki and Long Lake diversions were a valuable feature of the 1940 activities of the Commission.

No serious operating difficulties were encountered during the year. To an increasing degree the generating stations and transmission lines of Southern Ontario are being reinforced by interconnection. This results in a pooling of power resources which covers the whole of Southern Ontario, including the Niagara, Georgian Bay and Eastern Ontario systems, and greatly reduces the reserves which would otherwise have to be carried by the individual systems. Several local systems operated by independent municipalities and by private companies are also aided by being connected to the Commission's large networks.

During the past two years the average increase in monthly primary peak load has been about 12 per cent per year, but was held down in the last months of 1940 by the extension of daylight-saving time. The increase in energy requirements has been even greater, and during the past year, since war activities got well under way, the total energy requirements for primary purposes were 19 per cent greater than in the preceding year and by far the largest output of primary energy delivered by the Commission in any one year.

In the Northern Ontario mining fields the total primary load was about 20 per cent higher than in the previous year and reached about 205,000 horsepower.

Dr. Hogg states that the heavy demand for additional electrical service during the past year has necessitated an amount of engineering and administrative work that is unprecedented in the Commission's history. It was necessary not only to provide additional power supplies, but also to construct transmission lines and transformer stations for the wholesale delivery of power and to greatly increase distribution facilities throughout the Province.

The extension of the Ear Falls development in northern Ontario was completed in June. To serve the growing demands of the Georgian Bay system, work was commenced on the Big Eddy development on the Musquash river. In the Eastern Ontario system a development at Barrett Chute on the Madawaska river was commenced. It

will have a total rated capacity of 56,000 horsepower under a head of 154 feet. In the Eastern section of the Province substantial progress was made on the construction of a new 220,000-volt line, which, when completed, will extend from the eastern boundary of the Province to a new transformer station being constructed at Burlington.

The Testing and Research Laboratory of the Commission is giving valuable technical assistance in connection with the war effort of the Dominion.

The Bulletin of January 1941 gave a summary of data covering loads and finances of the Commission for the period covered by the Report and accordingly we are not repeating them here.

Revenue of Commission

The revenue of the Commission at interim rates from the municipal utilities under cost contracts, from customers in rural power districts and from other customers with whom—on behalf of the municipalities—the Commission has special contracts, all within the Niagara, Georgian Bay, Eastern Ontario and Thunder Bay systems, aggregated $37,399,535.90. The revenue of the Commission from customers served by the Northern Ontario Properties, which are held and operated in trust for the Province, was $5,066,193.82, making a total of $42,465,729.72.

25 Years' Record of Progress

In the Foreword to the Report several interesting diagrams covering the past 25 years' record in Ontario well illustrate the financial stability of the Hydro enterprise. Two of these showing the growth of the Hydro utilities of the co-operating urban municipalities are reproduced herein.

Municipalities Served

At the end of 1940 the Commission was serving 886 municipalities in Ontario. This number included 26 cities, 104 towns, 304 villages and police villages and 452 townships. With the exception of 14 suburban sections of townships known as "voted areas", the townships and 119 of the smaller villages are served as parts of the 184 rural power districts.

Municipal Electric Utilities

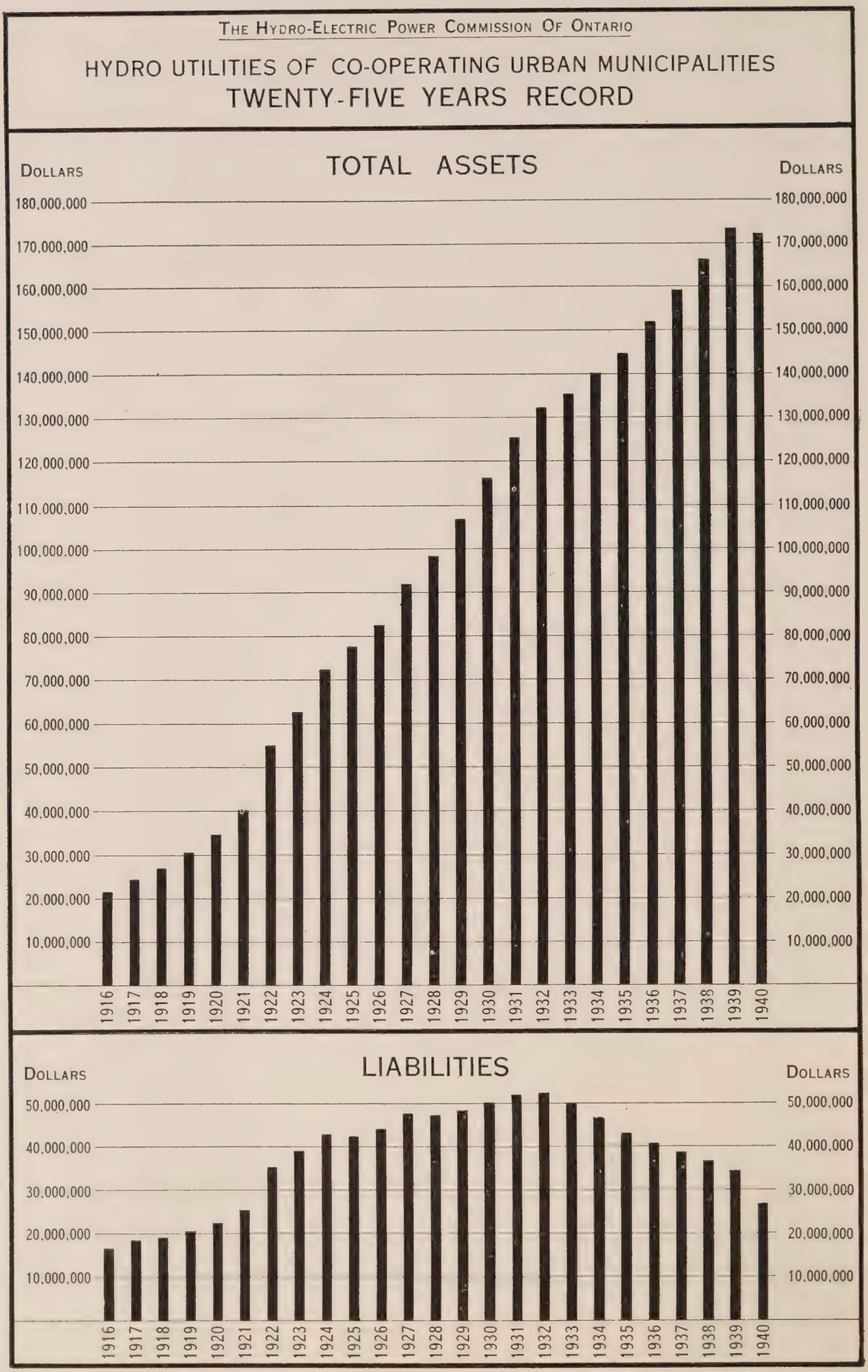
The following is a summary of the year's operation of the local electric utilities conducted by municipalities receiving power under cost contracts with the Commission:

Total Revenue collected by the municipal electric utilities		$38,025,287.44
Cost of power	$23,756,863.14	
Operation, maintenance and administration	6,114,892.07	
Interest	1,464,381.29	
Sinking fund and principal payments on debentures	2,389,723.60	
Depreciation and other reserves	2,644,127.10	
Total		36,369,987.20
Surplus		$1,655,300.24

With regard to the local Hydro utilities operating under cost contracts, the following statements summarize for each of the four co-operative systems administered by the Commission, the financial status and the year's operations.

Niagara System

The total plant assets of the Niagara system utilities amount to $81,328,811.01. The total assets, including an equity in the H-E.P.C. of $45,609,455.14 aggregate $144,568,329.62. The reserves and surplus accumulated in connection with the local utilities, exclusive of the equity in the H-E.P.C., amount to $75,337,559.11, an increase of $1,419,027.18 during the year 1940. The percentage of net debt to total


THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO
HYDRO UTILITIES OF CO-OPERATING URBAN MUNICIPALITIES
TWENTY-FIVE YEARS RECORD
TOTAL ASSETS
DOLLARS
180,000,000
170,000,000
160,000,000
150,000,000
140,000,000
130,000,000
120,000,000
110,000,000
100,000,000
90,000,000
80,000,000
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
1916
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1936
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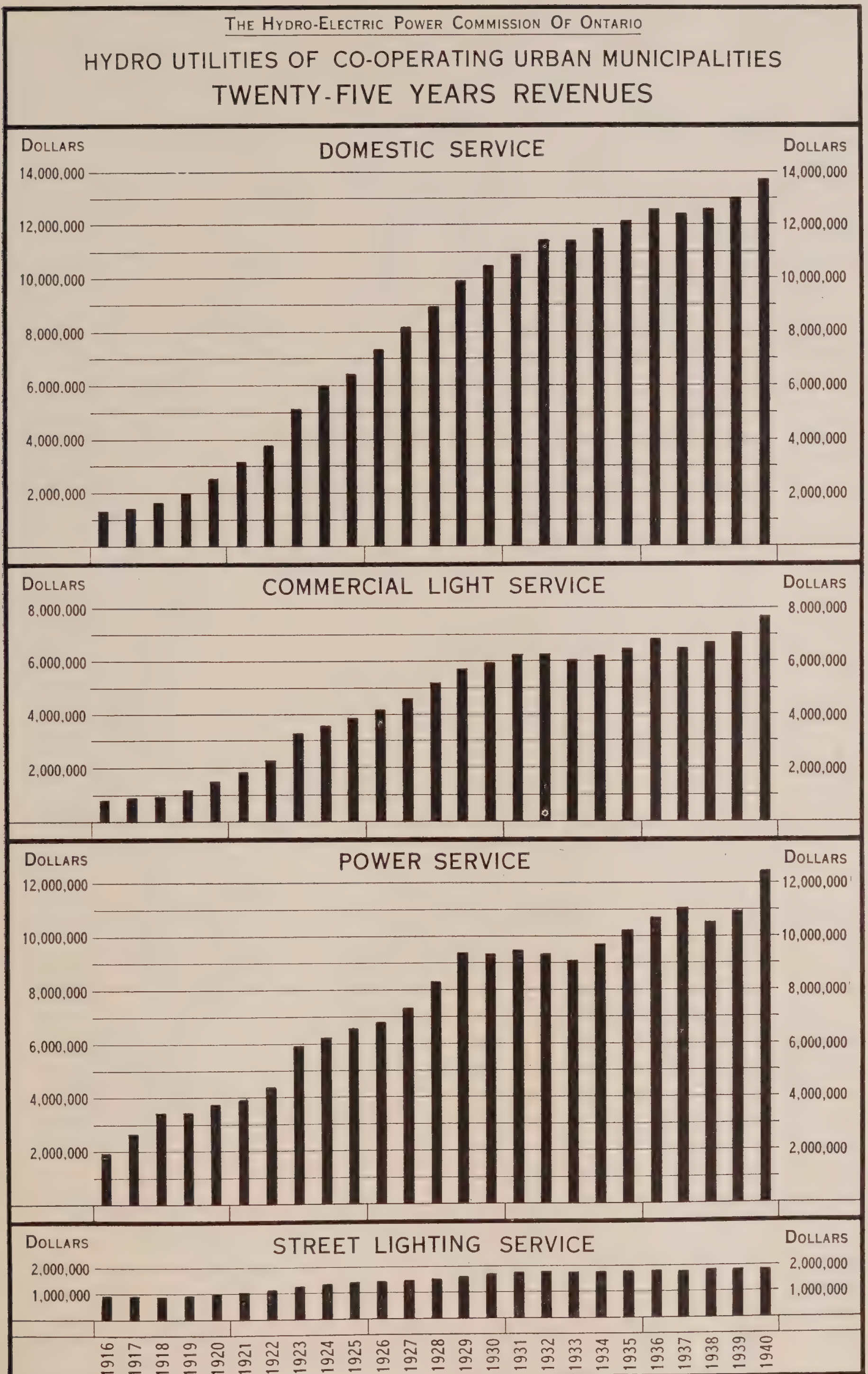
1938
1939
1940
LIABILITIES
DOLLARS
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000


The Hydro-Electric Power Commission Of Ontario
HYDRO UTILITIES OF CO-OPERATING URBAN MUNICIPALITIES
TWENTY-FIVE YEARS REVENUES
DOMESTIC SERVICE
Dollars
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
COMMERCIAL LIGHT SERVICE
Dollars
8,000,000
6,000,000
4,000,000
2,000,000
POWER SERVICE
Dollars
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
STREET LIGHTING SERVICE
Dollars
2,000,000
1,000,000
1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939 1940

assets is 18.6, a reduction of 2.4 per cent.

The total revenue of the municipal electric utilities served by this system was $30,677,444.27, an increase of $2,118,717.64 as compared with the previous year. After meeting all expenses in respect of operation, including interest, setting up the standard depreciation reserve amounting to $2,125,-698.12 and providing $2,223,707.93 for the retirement of instalment and sinking fund debentures, the total net surplus for the year for the municipal electric utilities served by the Niagara system amounted to $1,280,866.74, as compared with $661,463.52 in the previous year.

Georgian Bay System

The total plant assets of the Georgian Bay system utilities amount to $3,026,-575.25. The total assets, including an equity in the H-E.P.C. of $1,697,365.-75 aggregate $5,284,015.09. The reserves and surplus accumulated in connection with the local utilities, exclusive of the equity in H-E.P.C., amount to $3,192,112.33, an increase of $60,-939.28 during the year 1940. The percentage of the net debt to total assets is 11.0, a reduction of 0.9 per cent.

The total revenue of the municipal electric utilities served by this system was $1,330,359.48, an increase of $67,-474.96 as compared with the previous year. After meeting all expense in respect to operation, including interest, setting up the standard depreciation reserve amounting to $95,072.85 and providing $45,099.86 for the retirement of instalment and sinking fund debentures, the total net loss for the year for the municipal electric utilities served by the Georgian Bay system amounted to $18,182.98 as compared with a loss of $26,897.01 the previous year.

Eastern Ontario System

The total plant assets of the Eastern Ontario system utilities amount to $9,392,825.41. The total assets including an equity in the H-E.P.C. of $2,440,518.23, aggregate $14,640,965.-26. The reserves and surplus accumulated in connection with the local utilities, exclusive of the equity in H-E.P.C., amount to $10,243,898.36, an increase of $642,560.31 during the year 1940. The percentage of net debt to total assets is 9.7, a reduction of 1.9 per cent.

The total revenue of the municipal electric utilities served by this system was $4,051,036.67, an increase of $294,-312.10 as compared with the previous year. After meeting all expenses in respect to operation, including interest, setting up the standard depreciation reserve amounting to $254,994.50 and providing $101,843.09 for the retirement of instalment and sinking fund debentures, the total net surplus for the year for the municipal electric utilities served by the Eastern Ontario system amounted to $290,513.86 as compared with $162,451.40 the previous year.

Thunder Bay System

The total plant assets of the Thunder Bay system utilities amount to $2,887,-304.27. The total assets, including an equity in the H-E.P.C. of $2,710,337.-64, aggregate $6,535,501.20. The reserves and surplus accumulated in connection with the local utilities, exclusive of the equity in H-E.P.C., amount to $3,341,359.07, an increase of $55,-896.33 during the year 1940. The per-

centage of net debt to total assets is 9.6 a decrease of 0.2 per cent.

The total revenue of the municipal electric utilities served by this system was $1,336,533.62, an increase of $97,-291.79 as compared with the previous year. After meeting all expenses in respect of operation, including interest, setting up the standard depreciation reserve amounting to $48,060.93 and providing $9,273.30 for the retirement of instalment and sinking fund debentures, the total net loss for the year for the municipal electric utilities served by the Thunder Bay system amounted to $21,400.66, as compared with a net loss of $11,352.00 for the previous year.

The Blackout in Toronto

MUCH interest has been aroused among utility engineers in the practice blackout held in the Toronto area on June 18th, 1941. Not only was the blackout extremely effective, it having been estimated by those familiar with actual war-time conditions that Toronto was more effectively blacked-out than has been the practice in England. But an opportunity has been given to study the magnitude of the load-change occurring under conditions typical of North American cities.

The area which was affected by the blackout included not only the city of Toronto but also the surrounding suburbs of Leaside, Forest Hill, Weston, Mimico, New Toronto, Long Branch, Port Credit and Swansea, and Etobicoke, East York and Scarboro townships. These municipalities and districts are within the Toronto Regional Civilian Defense Committee (C.D.C.) Area No. 9.

The blackout was ordered to take place from 10:30 p.m. to 10:45 p.m. d.s.t., signals being given by fog-horns, fire-reel sirens, and in some instances by whistles. Three signals were given as follows:

1. Alert Signal, 10:20—10:22 p.m.
2. Warning Signal, 10:28—10:30 p.m.
3. All Clear Signal, 10:45—10:47 p.m.

The results of the blackout on the load curve of the Toronto Hydro-Electric System are of particular interest. Load began to fall away from normal about a half an hour before the warning signal was given. From an initial value of 170,000 kw. it fell to 160,000 kw. at 10:15; and at 10:30, when the warning signal ceased sounding, it was down to 69,500 kw., at which level it stayed for the fifteen minute period of the blackout. At 10:45 it increased sharply to reach a value of 163,000 kw. This value is estimated to have been somewhat greater than normal for the time of night. The decrease of 100,500 kw. gives only an approximation of the combined lighting and transportation loads carried by the System at the time of the blackout, customers in a number of cases having blacked out their establishments by dropping the whole

Toronto load curve during blackout period June 18, 1941.

of their power load as well as lighting.

The foregoing load values refer only to that portion of the total district load within city limits proper.

The majority of the street-lighting circuits within the city limits of Toronto are fed from primary circuits separate from the commercial and domestic supply, and are controlled by separate breakers located in either manually operated or supervised sta-

tions. A number of the downtown pillar lights and certain of the outlying feeders are supplied from adjacent twenty-four hour circuits through contactors energized from the nearest street-lighting circuit under manual control. Centralized control and the absence of photo-electric devices controlling local and restricted areas thus made it a simple matter to blackout street lights while maintaining other circuits alive. Only a few of the pillar lights and the lighting in several subways had to be patrolled and turned off by hand before the zero hour.

The Exhibition authorities co-operated with the System and turned off such of the lighting in the exhibition grounds as was not supplied directly from system feeders.

The supply to many illuminated commercial signs and bill boards is controlled by contactors energized off street-lighting circuits. The problem of their extinguishment was thus simplified for their owners.

All street lighting circuits were disconnected for the period 10:30 to 10:45 p.m. This was done on the exact minute according to clocks set by Toronto Police Department Switchboard time.

Certain essential lighting services had to be maintained in System premises. In attended stations all exterior lighting was extinguished and interior lighting was reduced to the minimum necessary for the carrying out of routine and emergency switching operations. Elsewhere, in unattended substations, system offices, shops, and stores, all exterior and interior lighting was extinguished prior to or at the sounding of the warning signal.

In the head-office building lighting had to be provided for the load and trouble dispatch offices and the telephone switchboard. The existing emergency direct-current service to these rooms and for corridors and elevators was made use of. Where venetian blinds were installed these were turned so as to screen off all light from view from above; elsewhere opaque blinds were used, or the lighting was disconnected.

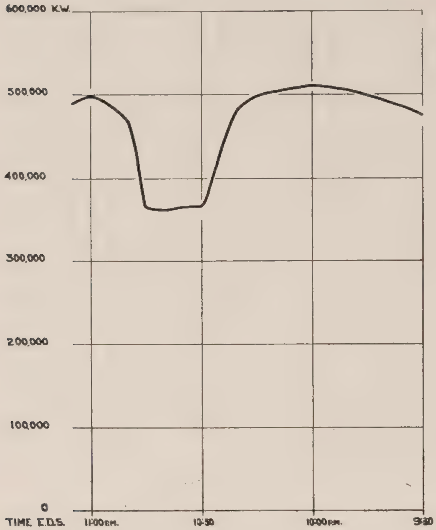
Attendants were stationed in all normally unattended stations during the period of the blackout.

The city police stopped all traffic for the period of the interruption except for fire reels and police cars, ambulances, and doctors' cars, and the trouble service vehicles of the utilities. While the System's trouble men had the right under this arrangement to travel during the period of the blackout, blue crepe paper was placed over the headlights as a means of identification and more closely to simulate war conditions.

* * * *

The Effect of the "Blackout" on June 18th, 1941, on the High Tension Municipal Load of the H.E.P.C.

The high tension municipal load comprises the majority of the municipal and rural supply in the Commission's Niagara system. It does not include the municipal and industrial loads supplied by the Commission in the Niagara peninsula, chiefly that area lying between the Niagara river and the Welland Ship Canal. The area which was affected by the "Blackout" included

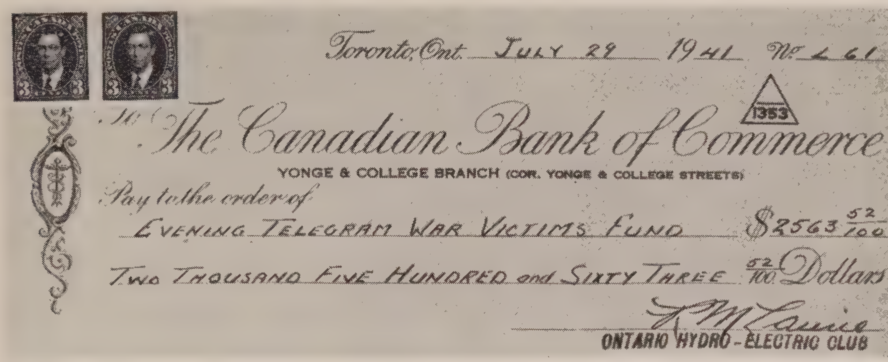


H.E.P.C. of Ontario high tension municipal load during blackout period at Hamilton and Toronto, June 18, 1941.

the city of Toronto and surrounding suburbs and the city of Hamilton.

The high tension municipal load rises to a peak condition at 10:00 p.m. d.s.t. On the four days, two days preceding and two days following the "Blackout", the average value at 10.00 p.m. was 540,000 kw., while on the day of the "Blackout" it reached a maximum for the night load of 510,000 kw. From this level the load receded faster than normal, reaching a value five minutes before the "Blackout" was scheduled to start of 428,000 kw. from which point it dropped to 365,000 kw. at 10:30 p.m. and remained at approximately this value during the period of "Blackout". At 11:00 p.m. the load returned to approximately normal value.

Barrett Chute development, Madawaska river. The chute on the Madawaska from which the development derives its name.



Donation to the British War Victims' Fund

DURING March of this year the Field Branch of the Ontario Hydro-Electric Club organized a committee for the purpose of conducting a campaign to collect funds to be contributed to the British War Victims' Relief through the Toronto Evening Telegram. As a result of this effort contributions totalling $2,563.52 were received from the Hydro field staff, and on Tuesday, July 28th a cheque for that amount was presented to a representative of the Toronto Evening Telegram. The presentation was made at the Hydro head office by Dr. Thomas H. Hogg, Chairman of the Commission.

* * * *

Dundas, Ontario,
July 25th, 1941.

Dr. Thomas H. Hogg,
Chairman Hydro-Electric Power Commission of Ontario,
620 University Avenue,
Toronto.

Dear Sir:—

With the permission of your Department Heads the following Committee of your employees was formed to solicit subscriptions for the British War Victims' Relief Fund from all employees of the Hydro Electric Power Commission of Ontario not participating in the Head Office War Charities Effort.

Chairman, W. H. Mills, Operating Dept.

Sec.-Treas., Miss A. M. Waring, Line Mtce. Dept.

Directors, Wm. Nattress, Rural Dept., J. A. Powell, Stn. Mtce. Dept., L. A. Catchpole, Stn. Const. Dept., I. Ritchie, Line Const. Dept.

The Toronto Office Hydro-Electric Club graciously agreed to act as banker for our fund and permitted us to operate under their charter, incorporating our Committee as a subsidiary of their Club.

Your Department Heads gave us their whole-hearted co-operation. This, together with the loyal support of your field staff, resulted in the collection of $2,563.52 which we have the honour to ask you to present to the victims of Hun brutality in the British Isles

through the Toronto Evening Telegram British War Victims' Fund.

Yours truly,

(Sgd.) W. H. Mills,
Chairman.

* * * *

July 29th, 1941.

C. A. Knowles, Esq.,
Managing Editor,
The Toronto Evening Telegram,
Toronto, Ontario.

British War Victims' Fund

Dear Sir:—

The Field Employees of The Hydro-Electric Power Commission of Ontario are happy to avail ourselves of your Fund for the transmission of this smali token of our appreciation and esteem of our kin in the British Isles for their glorious example of unfaltering courage in the face of Hun outrages.

These valiant people have set a standard of heroism which all peace loving people will be proud and happy to bequeath as a sacred heritage to future generations. Our debt to them is beyond human calculation.

Realizing this, we, with deep humility, offer this assistance in their distress and pray that we Canadians will ever be alive to our duty and privilege in this our obligation.

Yours sincerely,

(Sgd.) W. H. Mills,
Chairman,
Field Employees' Committee
British War Victims' Fund.

F. N. LEAVENS, Bolton

On Saturday, July 5th, 1941, Frank Nealon Leavens, secretary and commissioner of Bolton Hydro-Electric Commission passed away suddenly in his seventieth year.

Mr. Leavens was born in Pickering and went to Bolton fifty-two years ago. For the past fifty years he has been owner and publisher of the Bolton Enterprise, an Ontario weekly newspaper. He was active in civic and business accomplishments, having organized the Bolton Telephone Company, with which he was associated ever since, latterly as manager. He was also a director of the Ontario Independent Telephone Association.

He served for many years in municipal office and was reeve for three years. It was during his term as reeve, 1914, that Bolton entered into a contract for a supply of power from The Hydro-Electric Power Commission of Ontario. Delivery was made early in 1915. In 1930, Mr. Leavens was appointed secretary of the Bolton Hydro-Electric Commission, and has performed the duties of that office continuously until his death. The respect with which he was held by the people of Bolton was also reflected in his dealings with the Commission, of which he was a strong supporter. Those who associated with him always found him very likable and ready to cooperate in any way which would benefit the users of Hydro.

The 220,000 Volt System of the Hydro-Electric Power Commission of Ontario—II

By A. H. Frampton, Assistant Electrical Engineer, and E. M. Wood, Planning Engineer, H.E.P.C. of Ontario

At the Summer Convention of the Institute in 1930, E. T. J. Brandon presented a paper under this same title,[1] describing the design of the initial components of this system, which had then been in operation approximately one and one-half years. At that time, one and one-half circuits, having a combined length of 350 miles, were in service, transmitting approximately 110,000 kw. to a receiving terminal station in the Toronto area of 180,000 kv-a. capacity. At the present time, the Commission is operating a total of 1,000 miles of single-circuit 220,000 volt construction, with one receiving terminal of 420,000 kv-a. rated capacity and is placing into service immediately 45 miles of double-circuit construction and a second receiving terminal of 150,000 kv-a. capacity.

This paper presents a brief history of the development of the system and places on record the experience gained in 8,400 circuit-mile-years of operation of the transmission circuits. Data are presented regarding lightning outages and the behaviour of the circuits under sleet and conductor vibration.

These data are then used to indicate the reasons for certain revisions made in the design of new single-circuit construction carried out during 1940-41, and to indicate the factors that influenced the design of a new 45 mile double-circuit extension. The paper concludes with a discussion of the relay protection system and the improvements now being incorporated therein.

General System Arrangement

The 220,000 volt system under discussion forms part of the Commission's 25 cycle Niagara system, Fig. 1, which supplies a highly developed area of some 12,000 square miles in the peninsula formed by lakes Huron, Erie and Ontario. This system distributes power over approximately 1,350 miles of 110,000 volt lines. The total primary load, which equalled 710,000 kw. in December 1929, reached nearly 1,125,000 kw. in December 1940.

This 220 kv. system has been the channel over which all growth of load in the Niagara system has been supplied since 1928, from generating sources largely in the neighbouring province of Quebec. An initial 60,000 kw. was transmitted over the first circuit in October 1928, increasing to 515,000 kw. transmitted over three such circuits in December 1940.

Until this summer, this supply has been delivered at the Leaside receiving terminal, adjacent to the city of Toronto, which it will be noted lies at the easterly extremity of the main 110,000 volt system. This fact has in itself created problems of distribution, the

Paper presented to the American Institute of Electrical Engineers at Toronto, June 19, 1941.

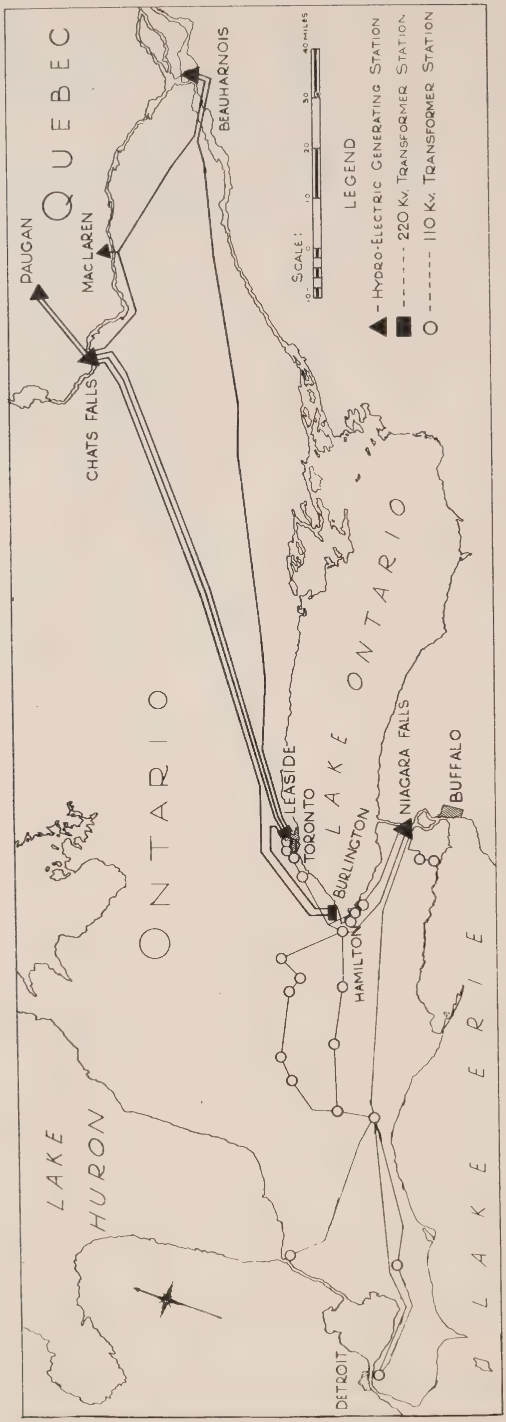


Fig. 1—The Niagara System of the Hydro-Electric Power of Ontario, showing major generating and transformer stations and 220 kv. and 110 kv. lines.

solution of which will be materially aided by the placing in service of the new terminal shown at Burlington.

Development of 220,000 Volt System

The 220,000 volt system was initially conceived as a two-circuit system, with a mid-point interswitching station, transmitting some 200,000 kw. purchased under contract from the Gatineau Power Company, from that company's Paugan Development some 230 miles east of Toronto. Later contractual undertakings and the construction of the Chats Falls development on the Ottawa river, brought the total capacity available from eastern sources to approximately 615,000 kw.

The third 220 kv. circuit was constructed in 1931, when the Chats Falls development was first brought into service. The connection shown from Beauharnois to MacLaren to Chats Falls was built during the depression years, to deliver the power which became available from the former sources to Chats Falls for transmission over the three-circuit system. This was an expedient, adopted as the most economical means of effecting this delivery, following an analysis of the transmission capacity of these three circuits in the light of the then existing knowledge of stability problems. This analysis indicated that, even without a mid-point interswitching station, the dependable capacity of these circuits, given proper fault clearance times, could be increased from an earlier rating of 330,000 kw. to approximately 450,000 kw.

The terminal capacity at Leaside has been increased progressively, by the addition of four 45,000 kv-a. banks, duplicate of the two banks originally installed, and two 75,000 kv-a. banks, making a total installed rating of 420,000 kv-a.

Until the outbreak of hostilities in September 1939, it was planned that this system would need to be extended for service in the fall of 1942. The outbreak of hostilities, however, brought the expectation of rapidly accelerated power demands and the construction of a fourth circuit from the Beauharnois development of the Beauharnois Light, Heat and Power Company, in the Quebec section of the St. Lawrence river, was immediately undertaken. The selection of a westerly terminus for that line presented a problem upon which considerable time and study has been expended.

The Leaside terminal, being located in the metropolitan area of the city of Toronto, in which approximately 40 per cent of the total primary demand of the Niagara system occurs, provided a convenient point of distribution for the power delivered during the building-up years. In later years, however, Leaside has been expanded beyond the capacity originally contemplated, so as to make the most efficient use of the transmission system, thereby creating an increasing distribution problem.

Furthermore, as is obviously desirable, the power transmitted over this system was purchased under contracts which require high load-factor deliveries, much higher, in fact, than the load-factor of the demands within the immediate vicinity of the receiving terminal.

For these reasons it has been necessary to distribute from Leaside, to gradually increasing distances, power and

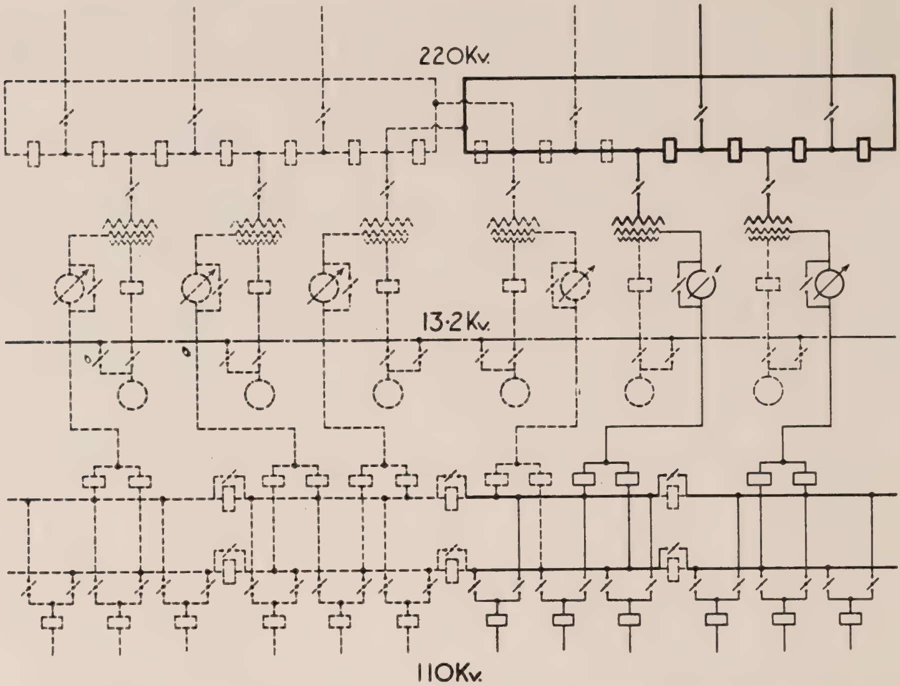


Fig. 2—Burlington 220 kv. receiving terminal. Proposed ultimate diagram for six-220 kv. circuits and six-75,000 kv-a. transformer banks. Initial (1941) installation in heavy lines.

energy delivered in excess of the Toronto area demands. This distribution distance increases and decreases daily, with the variations of local demand, and is considerably greater in the summer than in the winter. During recent summer months power generated 250 miles east of Toronto has actually been delivered to the immediate vicinity of Niagara Falls.

It had been planned that the second 220 kv. terminal would also be in the Toronto area, but on its westerly outskirts. Further study, in the light of the increased capacity of Leaside, has resulted in the new terminal being located at Burlington, some thirty miles west of Toronto. At that point the new station is adjacent to the rapidly expanding load area of the city of Hamilton and also is situated where a number of existing 110 kv. circuits intersect.

This new terminal is supplied by diverting to it the shortest of the existing 220 kv. circuits, namely, one originating at the Chats Falls Development, thus holding the longer Beauharnois circuit to its minimum length by terminating it at Leaside. In addition, a 220 kv. tie-circuit between Burlington and Leaside is provided, interconnecting the 220 kv. lines so that they operate as a four-circuit system. These two circuits are carried around the metropolitan area of Toronto and to Burlington on double-circuit structures, the first of such construction adopted by the Commission.

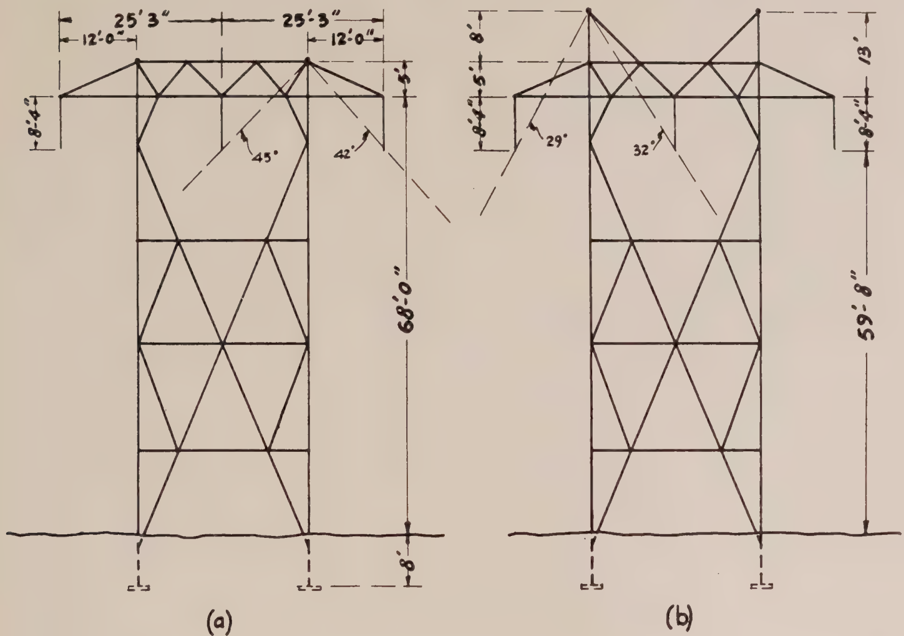


Fig. 3—(a) Outline of original single-circuit 220 kv. tower showing major dimensions and shielding angles.
(b) Corresponding outline of revised 1940 tower.

The Burlington transformer station is being constructed on a sixty-acre site, designed to accommodate ultimately six banks of three-25,000 kv-a., single phase, 220/110/13.2 kv., forced air-cooled transformers. Two banks totalling 150,000 kv-a. are being installed initially. A schematic diagram of the proposed ultimate station is shown in Fig. 2, on which the initial installation is indicated in heavy full lines. The addition of a third bank at this station will complete the existing phase of development, providing for the delivery of some 675,000 kw. over the four 220 kv. circuits. Beyond that point further delivery at Burlington will depend upon the development of new power resources, as for example, upon the Ottawa or St. Lawrence rivers.

Summary of Operating Experience

The first of these 220 kv. circuits was placed in service on October 1st, 1928, since when a total of 560 circuit-miles has been added, making a total of 790 circuit-miles in service as of March 31st, 1941. Of this mileage some 85 circuit-miles are not actually operated by the Commission, being located in the province of Quebec, but are included in the following record. The whole of this construction in general conforms to the designs described in the earlier paper, the standard suspension tower being shown in Fig. 3 (a).

In approximately thirteen years, 8,400 circuit-miles-years of operating experience has been secured and a total of 111 faults due to all causes have been experienced. Of these, four

TABLE I

LIGHTNING OUTAGE RECORD

Classified according to the type of fault.

Involving one wire and ground	56	59%
Involving two wires and ground	25	26%
Involving three wires	14	15%
Total	95	100%
Involving one circuit only	95	98%
Involving two circuits simultaneously	1	1%
Involving three circuits simultaneously	1	1%
Total outages due to lightning	97	100%

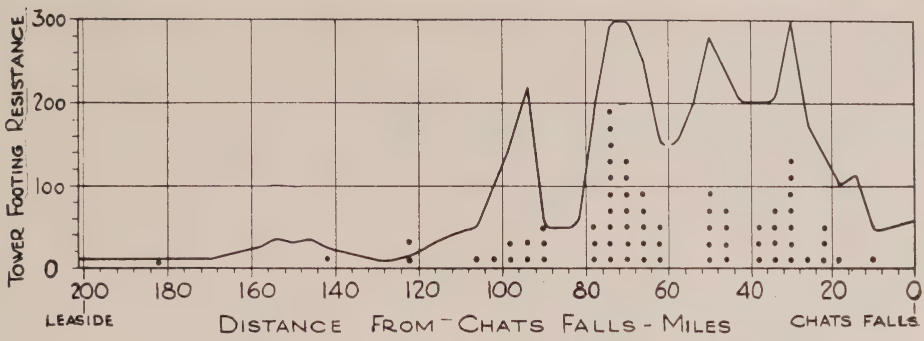
were occasioned by various construction hazards in the early years and eight were due to miscellaneous causes, chiefly external interference. Each of these faults involved only one wire and ground and, except in the period when only one circuit was in service, created no serious disturbance. It is of interest to discuss the salient features arising out of the remainder of this extensive operating record.

(a) *Lightning*

Of the remaining 99 faults experienced in this period, 97 are attributed to lightning, equal to an average of 1.15 lightning outages per 100-circuit-miles per year, in a territory in which the thunderstorm frequency is between thirty-five and forty storms per year. The classification of these lightning faults as to single-wire-to-ground, two-wire-to-ground and three-wire and as to those involving one, two or three circuits is given in Table I. The frequency of occurrence of such faults has varied tremendously; for example, three outages have been experienced within ten minutes; on another occasion, four within an hour and again five in one day and yet one period of eighteen months passed without a single outage.

These averaged data do not give a complete picture of the performance of these circuits. The three Chats Falls-Leaside circuits are constructed over terrain varying from rich farm land to rocky undeveloped bush country. The latter section, which extends almost continuously for a distance of about 90 miles, is characterized by surface rock formations with pockets of muskeg in the rock depressions. Towers are frequently erected on the rock outcrops. Low footing resistances are, therefore, difficult to obtain. In Fig. 4 an approximate footing-resistance profile for the Chats Falls-Leaside section is given, as compared to the known location of 70 of a total of 89 outages in this section attributed to lightning. It will be seen that some 90 per cent of the located lightning outages occured in the section of high footing resistance.

In Table II is presented an attempt to co-relate the lightning outage record with footing resistance. The data are presented first for the 70 located faults in the Chats Falls-Leaside section and then for all 97 faults, based on locations for those not traced, as estimated from relay target and oscillograph records. It will be observed that, in the territory where footing resistances are considered to be below 25 ohms, the



• Represents One Lightning Fault In The Respective Four Mile Section (5 Towers Per Circuit Per Mile)
Tower Footing Resistance Figures Are Average Values For The 60 Towers In Each Four Mile Section.

Fig. 4—Approximate footing resistance profile of three-220 kv. circuits, Chats Falls to Leaside, showing grouping of 70 located lightning outages.

TABLE II

Lightning Outage Record

Classified according to tower footing resistance.

(a) For 70 located faults on the Leaside-Chats Falls Circuits.

Average Tower Footing Resistance —Ohms	Number of Outages	Circuit-Mile-Years of Operation	Outages per 100 Circuit-Mile-Years
Under 25	3	2,150	0.14
25-50	6	1,950	0.31
50-200	16	2,000	0.8
Above 200	45	1,100	4.1
	—	——	
	70	7,200	0.97

(b) For all outages due to lightning.

Average Tower Footing Resistance —Ohms	Number of Outages	Circuit-Mile-Years of Operation	Outages per 100 Circuit-Mile-Years
Under 25	5	2,600	0.19
25-50	9	2,200	0.41
50-200	27	2,500	1.08
Over 200	56	1,100	5.1
	—	——	
	97	8,400	1.15

actual outage record approximates 0.2 outages per 100-circuit-miles per year.

Reference to Fig. 3 (a) shows that the tower design in these lines provides a shielding angle of 42 degrees and a ratio of "height of ground wire above power conductor to total height of ground wire" of 0.182. The experimental results of Wagner, McCann and MacLane[2] and the data presented by Waldorf[3] would indicate that good lightning performance could be expected and the record proves, that given low footing resistances, such has been the case.

Some crowfoot counterpoise work was done in the rock section along these three circuits during 1934-35. Short sections of highest footing resistance were so treated, with some success in lowering the measured values, but presumably the distances the crowfoot wires were carried to reach good grounds were too great to secure any considerable benefit.

(b) *Mechanical—Sleet and Wind*

In the southern part of the province of Ontario sleet storms of varying intensity may be anticipated both in the early and late winter seasons. December and March are the two worst months, though infrequently sleet may occur in any month from November to April. Storms have been experienced which have disrupted communication circuits and taken down wood pole construction. The phenomenon of "galloping conductors" has been observed, at not infrequent intervals, on various sizes and spans of conductors up to 605,000 cir. mils, a.c.s.r. at a span of 880 feet. Consideration must therefore be given to sleet conditions for all lines designed or constructed in this territory.

Two outages in the period under review are attributed directly to sleet, and these, incidentally, occurred within a few minutes of one another. Heavy sleet had formed on both power conductors and ground cables on certain hill tops, but only lightly on an intervening long valley span. As a result, the power conductors in the long span were pulled up by the unbalanced loading on the two sides of the adjacent suspension insulation, so that the ground cables, sagged to their normal loaded positions, appeared below the plane of the power conductors at mid-span. Two flashovers occurred, the second of which burned down a ground cable, resulting, on account of inaccessibility, in 27-circuit-hours of outage. In two other similar cases, a condition of unbalanced sleet loading was set-up, greatly increasing the sag of the ground cables without compensating sag of the power conductors, resulting in inadequate clearances. Fortunately, in these cases, the conductors were not disturbed by wind.

(c) *Mechanical—Vibration*

At the time of the construction of the first of these circuits (1927-28), the then relatively recent adoption of much longer spans and higher conductor tensions had brought the problem of conductor vibration strongly to the attention of transmission engineers. Remedial or palliative measures were as yet under investigation. In the original design this problem was recognized by providing, at suspension points, a reinforcement consisting of a 6-foot length of the conductor fastened at its outer

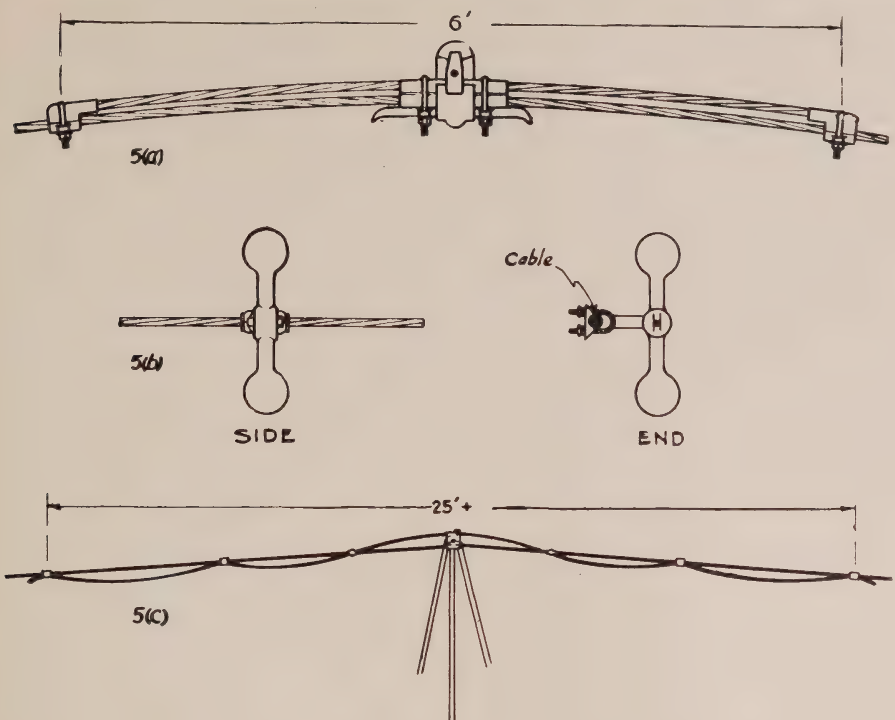


Fig. 5—(a) Conductor reinforcement on first (1927-28) construction.
(b) Torsional-type vibration absorber provided on one-half 1940-41 single-circuit construction; Stockbridge damper provided on remainder of such construction.
(c) Ground cable festoon used on 1940-41 construction.

extremities and supported above the main conductor in a double-seated suspension clamp, Fig. 5 (a). In the second and third circuits this form of reinforcement was replaced by the standard armour rods.

Each of these circuits was designed for a maximum conductor tension, at ½ inch ice, 8 pound wind and 32 deg. fahr., of 10,000 pounds, conductors being 795,000 cir. mils, a.c.s.r. having an ultimate strength of 28,500 pounds. This represents a maximum tension of 35 per cent of ultimate and also represents a tension at 60 deg. fahr. of 16 per cent of ultimate. These figures will be recognized as indicating a design in which conductor fatigue due to vibration might be anticipated.

Actually a considerable record of vibration has accumulated in operation, though nothing approaching a serious condition has been observed to date. Quite early a loosening of tower members was experienced, but this was remedied by the use of locknuts or their equivalent at all one and two bolt positions. Careful periodic examination of the conductors has revealed a few broken strands though such dam-

age does not indicate the need for any further palliative measures for some years.

Revisions in Design Incorporated in the 1940-41 Single-Circuit Construction

The recent extensive additions to this system were naturally not undertaken without re-consideration of the various design factors in the light of the experience enumerated above. It is of interest therefore to review such revisions as were made and to discuss the reasons associated therewith. The discussion is perhaps best arranged under the previous headings, though it is difficult to separate those adopted for improved lightning design from those which aimed at improvement in the mechanical performance.

(a) *Lightning*

The record indicates that good lightning performance can be expected of the original single-circuit tower, so long as footing resistances are kept sufficiently low. Perhaps, therefore, no change would have been made in the tower design were this the only factor, but as it was decided to raise the ground cables primarily for sleet operation, this revision may also be taken as improving the expectation of good lightning performance.

As illustrated in Fig. 3 (b), the two ground cables were raised eight feet above their original location, to a point of support 21 feet above the point of support of the power conductor in the suspension tower. This has had the result of decreasing the shielding angle to 29 degrees, while increasing the ratio of "height of ground cable above power conductors to total height of ground cable" to 0.263.

Measurements made by the meg-earth tester shortly after tower erection indicated that, in the earth sections, after consolidation of the back-fill, tower footing resistances generally would not exceed 15 ohms. In these sections, no treatment beyond the occasional crowfoot is contemplated. In the rock section, it was decided to lay a continuous counterpoise, consisting of 5/16 inch steel conductors available in salvage stores. These cables are in general buried to an average depth of 18 inches under the outer phase wires. Occasionally, however, they are taken around rock outcrops, when by so doing they could be buried, and, in isolated cases, are actually carried over the top of the rock. The performance of this new circuit will be carefully compared to that of the existing circuits as such performance will largely dictate whether counterpoise should be added to the older construction.

(b) *Mechanical—Sleet and Wind*

Our experience would seem to indicate that, under the operating conditions existing, sleet is more liable to form on the ground cables than on the power conductors and under such conditions, the vertical separation provided between ground cables and power conductors has proven insufficient. A. E. Davison, Transmission Engineer for the Commission, has actively studied this problem of conductor clearances. These studies are based on Lissajous figures[4] and the locus of motion of the conductor under "galloping" conditions is taken as the criterion. The axes of this motion have been determined empirically from recorded field observations and from analyses of motion picture records of a number of actual

occurrences. It is possible to at least approximately delineate the various loci. A tower design in which these approximate loci indicate adequate clearance between all conductors is considered much more satisfactory than one in which overlapping loci occur.

However, the extent to which this method should be applied to heavy conductor, long-span construction is still somewhat of an open question, being largely based on the behaviour of smaller conductors and shorter span construction than is involved in this case. No conclusive data are available indicating that 795,000 cir. mils, a.c.s.r. at 1056 feet spans will "gallop" at all, and even if it does, whether it will be in one continuous loop between the points of support or in something of a wave motion raising not more than one-half the span above its normal position at one time (that is, in half-loops). Oldacre and Wollaston[5], in describing the Powerton-Crawford line, illustrated the use of Lissajous figures and assumed the movement of the conductor in one loop.

In our case, however, a substantial mileage of towers was available in stock and much quicker deliveries could be obtained if the basic original design was not changed. This design was based on a longitudinal loading equivalent to ½ inch ice and 8 pound wind, but with the transverse loading increased to ¾ inch and 11 pound wind, the latter increase an added factor of safety since considered unnecessary. It was decided that part of this excess strength could be utilized to provide greater vertical separation between ground cables and power conductors, though in designing this improvement it was considered sufficient to assume movement of the conductors in half-loops only. It will be noted in Fig. 6 (a) that the re-design has removed the loci of motion of the ground cables from those of the phase conductors, providing adequate clearances under the assumed conditions. The ice-loaded mid-span position of the ground cable at rest, as compared to the corresponding position of the unloaded phase conductor, is also shown, indicating the maintenance of substantial clearances even with a ¾ in. ice differential.

(c) *Mechanical—Vibration*

The balance of the excess strength in the original tower design has been utilized to increase the ruling span from 1056 feet to 1150 feet. In order to maintain the same ground clearance at this longer span, the higher strength 26x7 strand, 795,000 cir. mils., a.c.s.r. has been used, strung to a maximum designed tension of 12,000 pounds. Based on an ultimate strength of 30,900 pounds, the designed maximum and "60 degree" tensions therefore approximate 39 per cent and 17.6 per cent of ultimate strength respectively.

The lengthening of the span in the new circuit was based partly upon the vibration record of the existing circuits and partly upon the favourable results obtained from an extensive laboratory and field investigation of damper design and performance.[6] It is felt that the development in this field now safely permits securing the economy inherent in longer spans and higher conductor tensions. The full possibilities in this connection were not realized in this case, due to the decision to retain the basic original tower design, but had a completely new design been permitted,

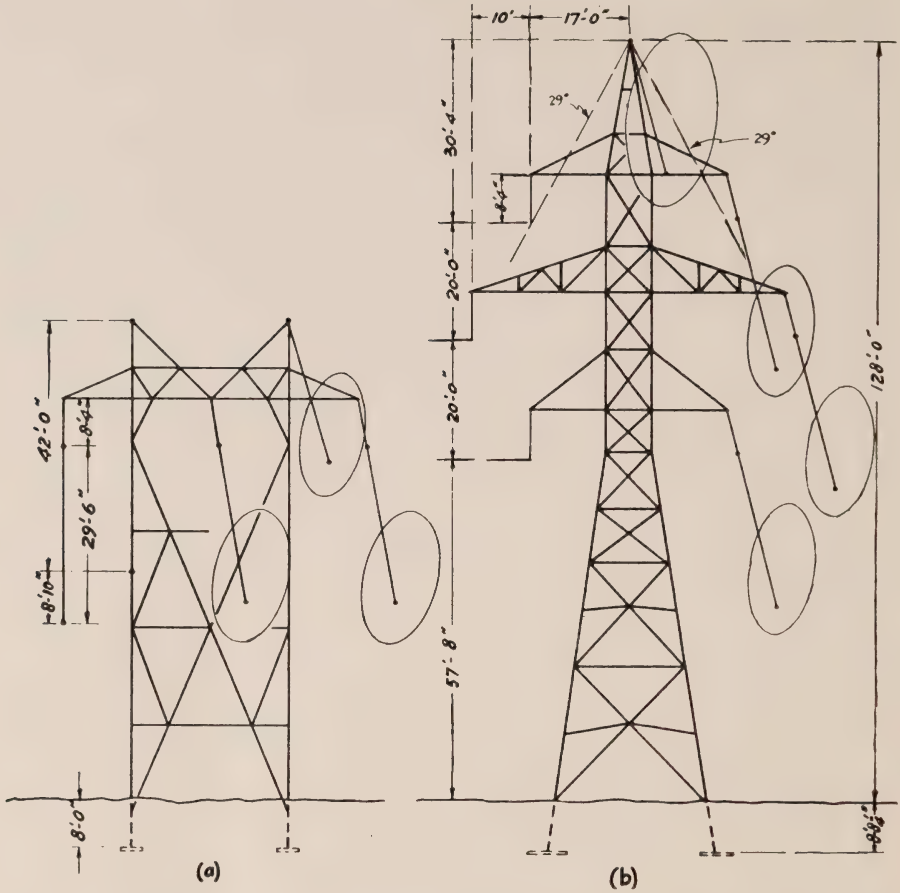


Fig. 6—(a) Clearance diagram (Lissajous figures) for 1940-41 single circuit construction. Loci based on half-loops, i.e., movement of quarter-point in suspension span. Note also mid-span positions of ¾ in. ice-loaded ground cable and unloaded phase conductor.

(b) Corresponding diagram for 1941 double-circuit construction. Note full loop movement of ground wires assumed at 880 ft. span.

spans as great as those encountered in some other recent construction would have been given serious consideration.

Associated with this increased span length the application of vibration absorbers was decided upon, rather than the previously used armour rods. Approximately one-half the line is equipped with the Stockbridge damper and one-half with the torsional damper, Fig. 5 (b), developed in the Commission's laboratory and described in a companion paper by G. B. Tebo.[6] Both dampers are used singly, that is, two

per span. Vibration of the ground wires is protected against by the use of festoons, Fig. 5 (c).

Double Circuit Construction Leaside to Burlington

In considering the two-circuit extension of these 220 kv. lines, from the existing terminal at Leaside to the new terminal at Burlington, a number of factors were brought into consideration. Single-circuit construction was initially considered, the Commission not having previously operated any double-circuit construction at 220 kv. In fact, there had been evident in the Commission's engineering a tendency to avoid such construction at all voltages, in favour of various single-circuit configurations. However, as some twenty miles of the Burlington extension necessarily encircled the metropolitan area of Toronto, this viewpoint was brought sharply into conflict with the question of right-of-way costs. The final decision was in favour of the double-circuit construction, though it will be noted that a relatively conservative design has been adopted.

The initial decision was to adopt a span of 880 ft., utilizing 795,000 cir. mils., a.c.s.r. at a maximum designed tension of 10,000 pounds. However, a change in this decision was brought about by the exigencies of the present situation and the line is actually being constructed utilizing the type HH segmental, hollow-core, copper conductors, 500,000 cir. mils, 1.02 inch outside diameter, seven segments, having an ultimate strength of 21,200 pounds. At the 880 ft. ruling span the maximum designed tension, at ½ in. ice, 8 pound wind and 32 deg. fahr., is 9,500 pounds, the 60 degree tension being 4,700 pounds, equivalent to 45 per cent and 22 per cent of ultimate respectively.

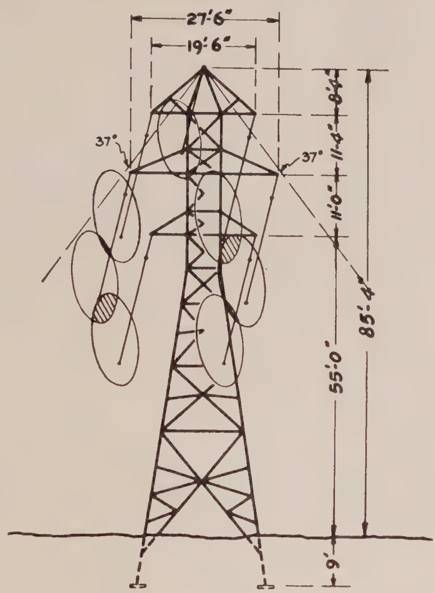


Fig. 7—Clearance diagram for 1920 type 110 kv. double-circuit construction—one-half loops only—Note overlapping loci indicating anticipation of sleet outages.

The tower design adopted is shown in Fig. 6 (b). It will be noted that a single ground cable is used, located at the tower peak, 30 ft. above the point of support of the upper phase conductor in the suspension position. A shielding angle of 29 degrees and a ratio of "height of ground wire above power conductors to total height of ground wire" of 0.236 results. Footing resistance data on this construction are not yet available, but the line being all in good agricultural land it is not anticipated any particular treatment of the footings will be found necessary.

Again in the new double-circuit con-

struction the same principles of design for sleet operation were used. It has been found more difficult to provide adequate clearances economically in this type of structure than in the single-circuit design. For example, in an earlier 110 kv. design, utilizing 605,000 cir. mils, a.c.s.r. conductors at 880 ft. spans and providing a 4-foot offset of the centre phase wire, Fig. 7, actual outages due to "galloping" have been experienced. That these outages might be anticipated, however, is indicated when the design is analyzed by means of Lissajous figures, though it will be seen that rather extensive revisions will be needed to effect full clearances. The clearance diagram for the 220 kv. design finally adopted is shown in Fig. 6 (b), based on half-loop movement of heavy copper power conductors but full loop movement of the relatively light ground cable.

No special precautions are being taken to protect this double-circuit construction against conductor vibration. The extensive studies reported by other authors are interpreted as indicating that, except perhaps in certain cases, no such precautions are necessary. Furthermore, it was decided that no particularly special provisions would be made in the suspension clamp, Fig. 8 (a), and that copper compression joints, Fig. 8 (b), would be used for both straight joints and dead-end assemblies. Time has not permitted complete investigation of this latter practice, which is at variance with the practice adopted in certain other lines utilizing this form of conductor,[7] but, as the full strength of the conductor is developed in these new joints and as the mass of all parts subject to possible vibratory stresses is reduced to a minimum, no objectionable operating experience is anticipated.

A structural revision incorporated in the double-circuit tower consists of designing the lower panel so that all diagonal connections are made above grade. In earlier designs, including the single-circuit 220 kv. construction, the point of connection of the lower diagonals and the main legs is located below ground level. In this climate and particularly in clay soils, frost heaving has been found to occur which reacts against this below-grade diagonal, causing bending and in some cases actual failure.

Relay Protection and System Stability

It is finally of interest to describe briefly the relay protection provided on this 220 kv. system and to discuss the improvements being made, both in the existing protection and in the protection of the newer construction, associating these improvements with the operating record and with the data obtained from Network Calculator analysis of the system.

For "phase" faults, the earlier relaying consists of directional, two-stage, impedance distance type. The instantaneous range of such relays is set to cover 85 to 90 per cent of the line length, the overlapping second range set to cover the remainder of the line and being given a definite time delay of 0.6 to 0.8 seconds. This protection effects simultaneous clearance of all faults in the mid-section of any line, but results in delayed opening of the distant breaker for end-zone faults.

For "ground" faults, similar protection is used, except that the relays are

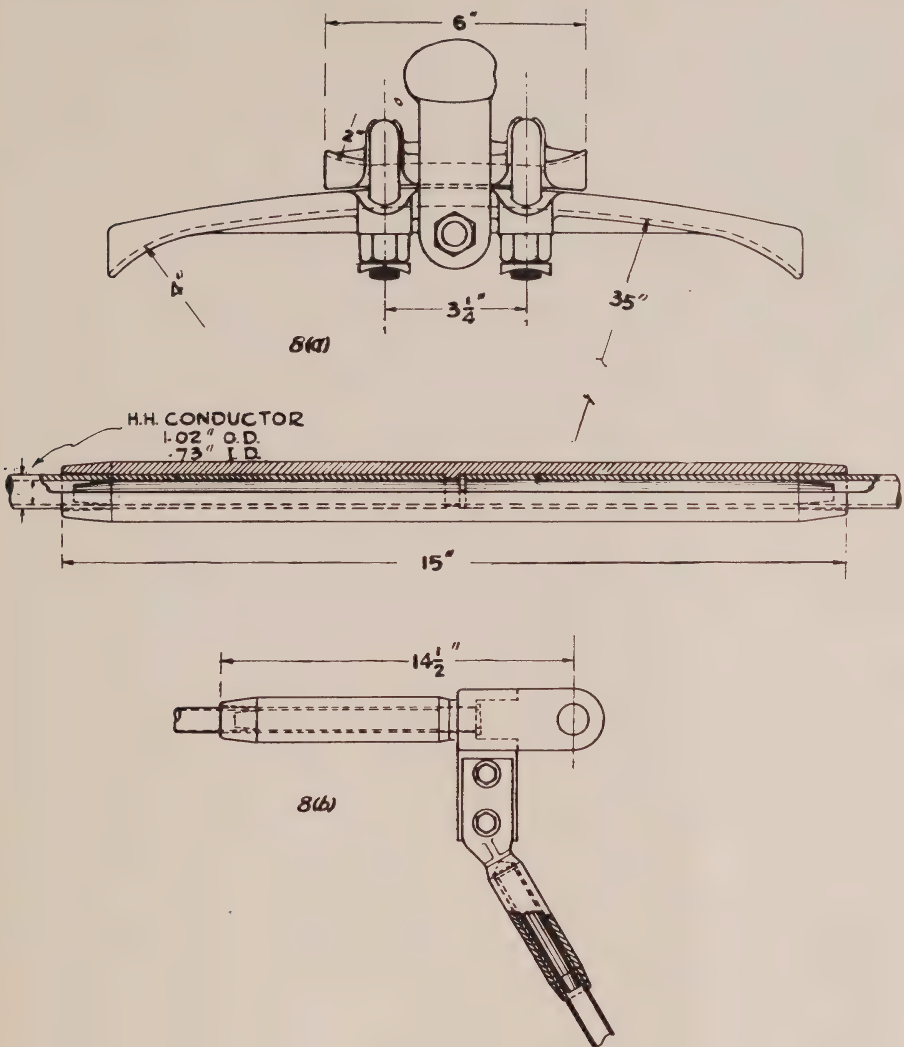


Fig. 8—(a) Suspension clamp adopted for type HH segmental copper cable, 500,000 cir. mils, 1.02 in. outside diameter. Span 880 ft., maximum designed tension 9,500 pounds, 45 per cent of ultimate strength.

(b) Jointing and dead-end assemblies for type HH copper conductors.

supplied with line residual current and phase to ground voltage and the instantaneous range is set to cover the whole length of the line, with some margin if the remote end is open. This results in simultaneous clearance of mid-section faults, though it also effects sequential clearance of faults in the end zones, that is, clearance without the delay associated with the timed second range.

Certain of the line sections terminate

in breakers of earlier design, which originally gave a clearance time, with instantaneous tripping, as high as 0.5 to 0.6 seconds. The more modern equipment clears within 0.2 to 0.25 seconds. Improvements have been made from time to time, in the original relaying and in the older circuit breakers, so that total clearance times now vary from 4.5 to 10 cycles, with an average of about 6 cycles (based on 25 cycles) for all faults except those cleared by the second ranges.

This protection, though admittedly below present-day standards, has nevertheless given adequate service during the building-up period on this system. Fortunately, all but a very few of the 39 multi-phase faults have occurred in the high-footing-resistance territory in the mid-section of the Chats Falls-Leaside lines, where this protection effects simultaneous clearance.

Improvement necessary in the protective equipment, when operating at the higher recent loadings, has been the subject of several Network Calculator studies. These studies bring out quite clearly the inherent stability of a 25-cycle system. Assuming simultaneous clearance times of 0.2 to 0.25 seconds, as would be obtained with standard modern equipment, it is found that the three-phase fault may be adopted as the stability criterion, rather than the two-wire-to-ground fault usually adopted in 60-cycle systems.

In Fig. 9 is presented a family of curves obtained in such analysis, which indicate the relative severity of different types and locations of faults. At a loading of approximately 150,000 kw. per circuit, Curves A and B indicate that three-phase faults near the generating source must be cleared simultaneously in approximately 0.2 seconds, if stability is to be maintained. If such faults occur away from the generating sources, Curve C indicates that the increased loading of generators thereby created is sufficient to maintain stability with simultaneous clearance at 0.25 seconds. Curve D shows the relatively lesser severity of the two-wire-to-ground fault, which does not disturb

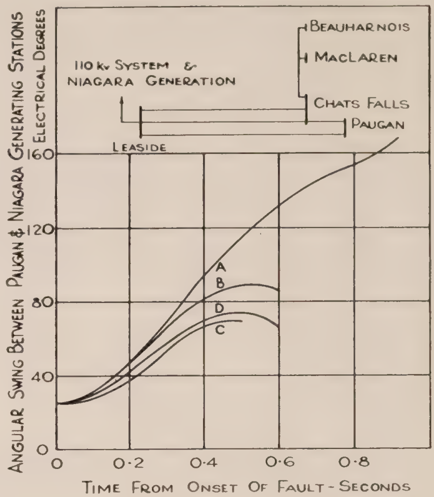


Fig. 9—Stability curves for three-circuit 220 kv. system, at loadings of approximately 200,000 h.p. per circuit.

A. Three-phase fault at Chats Falls, cleared sequentially in 0.2-0.5 seconds—unstable.

B. Three-phase faults at Chats Falls, cleared simultaneously in 0.2 seconds—stable.

C. Three-phase fault 30 miles west of Chat Falls, cleared simultaneously in 0.25 seconds—stable.

D. Two-wire-to-ground fault at Chats Falls, cleared sequentially in 0.2-0.5 seconds—stable.

the system stability with sequential clearance as long as 0.2 and 0.5 seconds. These results are taken to indicate that, with protective equipment effecting simultaneous clearance of all faults in 0.2 to 0.25 seconds, loss of system stability at loadings of 150,000 kw. to 170,000 kw. per circuit need not be anticipated.

It is proposed to attain this aim by superimposing carrier pilot control on existing and on all new two-stage impedance relaying. With the exception of the new Leaside-Burlington line, where standard "transfer-block" carrier relaying is proposed, a system of transfer-trip carrier control is being developed. The first of this equipment is being installed on the Beauharnois-MacLaren-Chats Falls connection and on the new Beauharnois-Leaside circuit. It consists of 400 watt carrier communication transmitters, single-frequency voice-actuated, the speech frequency range being limited to a band of 200 to 2,500 cycles. Tone generators will be used to transmit relay control signals, which operate to remove the time-delay feature of the distant-end second-range relays. Thus simultaneous clearance is obtained over the full line length, the speed of clearance being limited to that of the various terminal breaker equipments. This protection is as yet experimental and its performance in service will form an interesting study.

Conclusions

1. Operating experience with some 8,400 circuit-mile-years of 220 kv. single-circuit overhead line construction is submitted, which to a high degree confirms conclusions which may be drawn from the application to designs of published principles derived from theoretical and experimental analysis.
2. Changes made in the latest designs of towers to provide improved operation under sleet conditions also provide desirable improvements in design against lightning.
3. Counterpoise on towers of high-footing-resistance which has largely been omitted on earlier construction is being installed on 1940-41 lines.
4. Standard two-stage impedance type relay protection has given good satisfaction on these lines. To provide the best operation under heavy line loadings, carrier-current features are being superimposed on both new and old relaying to extend high-speed simultaneous fault clearance to cover the full length of each line.

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Universal Type Flat Rate Water Heater Tank Cover

A universal type flat rate water heater tank cover has recently been made available to the municipalities incorporating suggested improvements to overcome some difficulties experienced with the previous cover.

The universal type is suitable for either strap-on or immersion type heaters. The size designation is the same as the standard markings for water storage tanks., i.e. 30-40-52-66-82.

The universal assembly is in two pieces and with the insulation in batt form. It is now possible to remove the upper or lower section of the tank cover and insulation material and replace the same without disturbing the other section.

The new cover is split down the front to overcome the difficulty of the removal of the tank cover when placed close to a wall where little or no room is available to unfasten the screws holding the cover together. The top lid has been made with a much larger opening for the piping. The heater head and thermostat openings are considerably enlarged.

The complete cover assembly with set of insulation batts and instruction sheet is now packed in an individual carton. It is expected that with the new cover and insulation in batt form, the standard of water heater installations will be somewhat improved as the insulation material can be properly placed before the cover is assembled, making sure that the tank is evenly insulated.

Place

Base Ring support.

Base Ring—making sure the diagonal cut in this ring straddles a supporting lug.

Place

Heaters.

Place

Thermostats.

Universal Type 2-piece cover suitable for both Immersion and Strap-on Heaters.

Cover size designations same as tank size; i.e., No. 30, No. 40, etc., etc.

Place

Lower insulation sidewall Batt interlocking the wire mesh to hold snug to tank.

For better operation when openings are not adventageously placed in storage tank, use Strap-on Type Heaters.

Place

Upper insulation sidewall Batt.

Cut away insulation material and wire mesh covering heater head and thermostat. Pull out thermostat lead wires ready for wiring up.

When installing Immersion Type Heaters use Box Type or Square-jawed wrenches only. Make sure Strap-on Heaters are snug to tank and that the heating element does not straddle rivets, seam of tank or other obstructions.

When installing thermostats make sure that they are mounted above heaters, if this is not possible place to the side but never below. Make sure thermostat does not come in contact with heaters.

The installation of the cover is much simpler and easily accomplished as the pictures from the instruction sheet show.

Place

"AWH" wire connecting heaters and thermostats.

White wire—neutral.

Red wire—flat rate supply.

Black wire—booster supply.

Place

Lower side-wall section.

Place

Upper side-wall section pulling "AWH" wire through the No. 40 bushing into the 4-in. Junction Box.

Place

Top insulation Batt using the surplus from this Batt and the cuttings from heater head and the thermostat opening to insulate Box Type Covers.

Place

Split Type Top Covers.

When wiring use No. 20 bushings in heater head where "AWH" wire enters, No. 40 bushing is used at the 4-in. Junction Box mounted on the upper section of the side-wall casing.

More complete information regarding Flat Rate Water Heater Equipment installations may be found in the Instruction Manual S.P. 110. Sales Promotion Dept.

THE BULLETIN

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William Hogg

WHEREVER Hydro construction is being carried on, a deep sense of loss will be felt in many hearts when it is known that Bill Hogg has passed away. He died in Toronto General Hospital on August 27th after a comparatively short illness, at the age of 71. Many of his years were spent in whole-hearted service to the Commission wherever rock or earth had to be moved, concrete put into place or machinery set up to do such work. Many power developments beginning with the Ontario Power Company away back, the Queenston Development and several powerhouses since then from Ear Falls in the far North West to the one at Big Eddy in Muskoka which is still under construction, owe part of their existence to his labours.

What we shall miss most will be Bill's genial personality, his sound judgment and invariably willing help, and that distinguished presence of his which gave a cachet to whatever circle he might be in. Modesty was one of his outstanding characteristics, yet he could be the life and soul of a party. Our recollections of him will always be pleasant ones.

Electricity in Canada 50 Years Ago

THE Golden Jubilee number of *Electrical News and Engineering* contains a section headed "Highlights of the Half Century, 1891-1900" which contains items for the different years from 1891 to 1900, and from that date up to the present. In 1891 it was stated that there were between four and five hundred electrical installations with electric lighting and power plants being daily installed in every part of the country. That publication states that these four or five hundred small generators having a total capacity that would not exceed 40,000 h.p. may be called the beginnings of the Canadian electrical industry, which now has a primary power installation in central stations alone of around 8,000,000 h.p. Some of the items noted for the year 1891 are outlined hereunder.

It was reported that the city of Montreal led the way in the exclusive adoption of electric lighting for its streets. The Royal Electric Company there built extra stations "of immense power" during 1890. Quebec had extended its service by the introduction of large generators to operate incandescent light. These were a.c. machines installed at Montmorency Falls 14 miles away.

In Toronto the city closed a contract for five years for an additional illuminating capacity of 400 lights. Central stations were having difficulty in the larger centres keeping up with the demand for electric lighting.

Electric street railways had been pronounced practicable, but there were a number of difficulties which seemed to be holding back any number of electric railway installations. There was objections to the "unsightly and cumbrous" overhead construction necessitated by electric street railways. There were many who advocated cars driven by storage batteries and the city of Toronto could not make up its mind as to whether a trolley system or storage battery system should be installed in that city. Comparative costs of electric versus horsepower were given by a representative of the Thomson-Houston Electric Company before the Street Railway Committee of the Toronto City Council, which showed that in some cases reductions had been made from 17 cents to 9 cents or 8 cents per mile in favour of electricity. While the politicians debated about the possible benefits of electric street railways, many centres across Canada were installing plants to operate street lights.

Among minor difficulties not now encountered, a case is sited where in Windsor, Ontario, a couple of thieves stripped some telephone wires from their poles and tried to sell them in a Detroit junk shop. Also the people of Rat Portage complained that their telephone service had been ruined or destroyed by the placing of electric light wires on the same poles with the telephone wires.

The first electric passenger elevator to be manufactured and operated in Canada was placed in service in the Sun Life Assurance Building at Montreal.

It was reported in 1891 that during 10 months the electric tramways at Victoria, B.C., had carried 720,000 pas-

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The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

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sengers. The Ottawa Electric Street Railway Company, Limited, was incorporated with a capital stock of $5,000,000. The first electric tramway for mining purposes in Canada was put into operation in the New Vancouver Coal Mines at Nanaimo, B.C. Electric light and some other electrical machinery were also installed at these mines. Montreal town clocks were regulated by electricity in the year 1891.

W. C. McDonald bequeathed $40,000 to McGill University for the endowment of a chair in Electrical Engineering. In Toronto it was reported that the first installment of electrical instruments has been received for the Electrical Engineering Department of the School of Practical Science and that the Department would be fully equipped shortly before the end of the year.

Some towns took their electric light calmly, while others considered the switching on of the first electric lamp just cause for celebration.

A street car put into service in North Toronto was said to be the first car to be heated with electricity in Canada. An item appeared in 1891 to the effect that a residence in Peterborough had been fitted with electric lighting apparatus.

Many schemes had been advanced in this year and prior to this time for the development of power at Niagara and transmission of that power to nearby cities. The electric lighting system in Niagara Falls itself was supplied by a steam driven generator. There had been talk of transmitting power to Buffalo and even to New York from Niagara and also to Hamilton, London and Toronto, but in 1891 it appeared to be commercially impracticable. Alternating current motors were not in use yet, so only d.c. distribution was considered generally. Any scheme brought forward embodied in it either d.c. transmission at low voltage or a.c. transmission at what was considered to be a very high voltage (about 20,000 volts) with subsequent conversion to d.c. at the receiving end.

During 1891 the first mill ever established in the Dominion for the manufacture of copper wire was built in Montreal by the Dominion Wire Manufacturing Company.

Typical section of Queen Elizabeth Way before planting of centre strip. Eventually the poles will be hidden by the growth of trees. Welded steel mast-arms are used to support the luminaire 26 feet above the pavement and over-hanging some 3 feet. Poles are Class 5, western red cedar, shaved and stained green with 1/2-inch penetration creosote treatment of butts.

World's Largest Stretch of Lighted Highway

By R. E. Jones, Assistant Engineer, Distribution Section, Electrical Engineering Department, H.E.P.C. of Ontario

THE world's longest continuously lighted artery is the Queen Elizabeth Way in Ontario, extending from Toronto to Niagara Falls, a distance of 70 miles, with a further extension of 20 miles proposed to Fort Erie, opposite Buffalo, N.Y. This is a heavily travelled road through a thickly populated industrial area. The military value of such a road, according to the Department of Highways, was a factor in its construction during the war. It is well lighted throughout for safe night driving, making use of the silhouette principle instead of direct illumination.

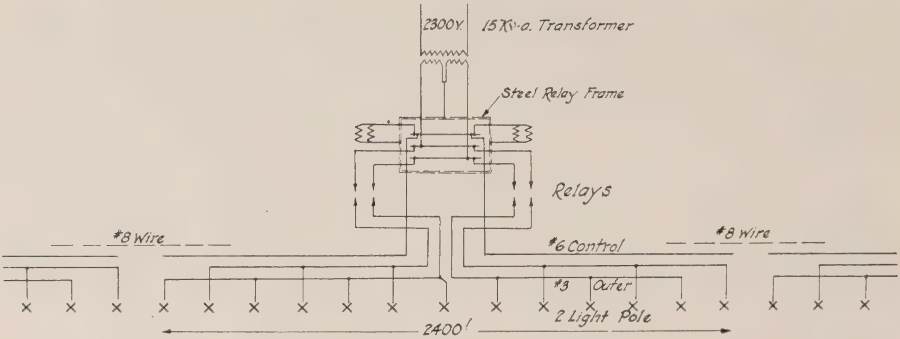
There are two concrete lanes, each 20 - 23 feet wide, with centre boulevard of 28 - 30 feet.

The position of the poles which is in the centre of the boulevard was decided upon after experiments had

Route of Queen Elizabeth Way.

On curves, standard spacing is reduced from 200 to 150 feet. Incandescent luminaires have 6000-lumen multiple lamps.

In a section where local conditions necessitated a narrow dividing strip, mast-arms are shortened to maintain the standard 3 feet overhang of the pavement.



Multiple Circuit Diagram. Lighting cables are No. 3-600-volt rubber and lead, with a similar No. 6 cable for control. Between sections a No. 8 bare wire is used to add to the conductivity of the one lead sheath at that point.

Cable riser at each pole consists of a single conductor, No. 8 R. & L., cable beneath wooden moulding from below ground to the mast-arms. As the lead sheath is used as the grounded side of the circuit, the pothead is attached to the cable by belling out and clamping the lead beneath a bushing. There is a ground screw on the side of the pot-head, and asphalt is used to seal the cable inside the body.

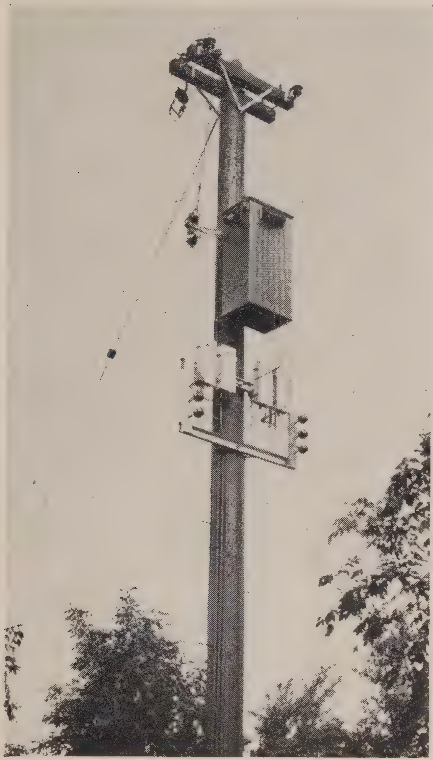
been made with various arrangements. This results in a minimum number of poles, and the poles are structurally balanced. The buried cable is multiple with full photronic control.

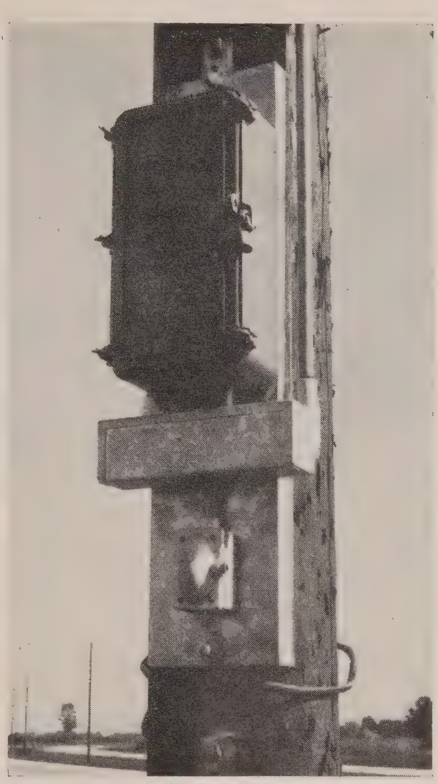
Power circuits were available along the entire route, which was one factor in the decision to install a multiple instead of a series system. When, as occasionally happens, a pole is knocked down, the balance of the circuit remains in service and the exposed conductor is of no higher voltage than 115.

On account of cheap power and the higher cost of equipment in Canada, incandescent lighting was selected. Some sodium units were purchased and are now used in place of standard incandescent units to mark intersections where the usual type of signal is not desired.

Lamps are 6000-lumen, 405-watt, multiple type with a life of 3000 hours. They are replaced semi-annually on a group replacement schedule.

Power is purchased at 2300 volts.

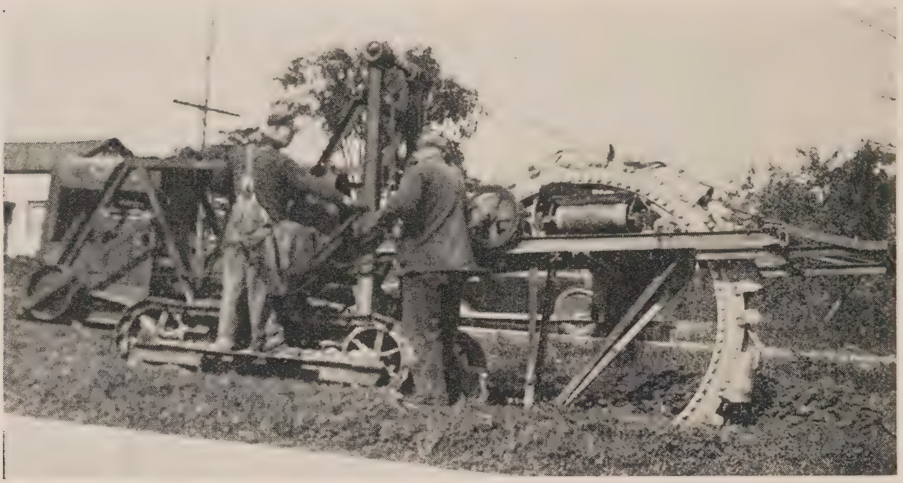




A standard distribution transformer is located at the side of the road each half mile. This is supplied at 2300 volts from an existing rural circuit. Below the transformer is a steel rack supporting 4 relays and a 3-wire bus. Transformers are painted green to identify them as road lighting equipment.

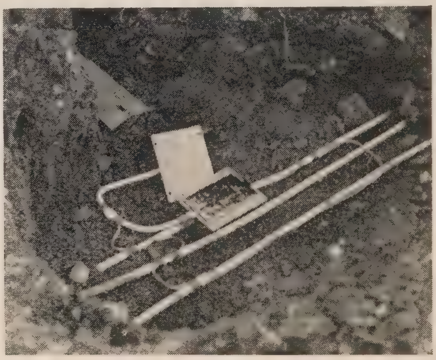
A photronic control is installed each 6 miles to turn the lights on and off. The controller, together with fuse and connection box, and lock switch to permit turning on in daytime for servicing, are mounted on a steel channel. In the daytime, the controller energizes the control cable which holds open all the relays in the section. Thus, failure in the control circuit will turn the lights on in the daytime, instead of turning them off at night.

The installation is owned and operated by the Department of Highways of Ontario. Engineering and construction was carried out by The Hydro-Electric Power Commission of Ontario.



Trench is dug near the pavement by machine, and backfilling is done with a scraper.

Cables are placed in the trench by hand, one at a time. For identification, one line cable is painted red opposite each pole as it is installed. As this part of the boulevard will never be disturbed by placing of sign posts or trees, cable cover blocks are used on lateral runs only.



Taps to the main cable are made by removing the lead sheath and making a soldered and rubber and friction taped joint. The joint is then placed in a slotted iron or wood box and filled with "crack-filler" asphalt. As the lead sheaths act as a neutral conductor, they are all bonded together at each tap point. For a bond, No. 6 copper wire is used, attached to the lead with a binding of No. 16 tinned copper wire and soldered.

At the Toronto Entrance steel standards were used on one side of each traffic lane. The monogram represents Elizabeth Regina.

For the concrete bridges, a suitable standard was designed by the Department of Highways. It has a projection of 10 feet and is of welded steel pipe.

Anglo-American Responsibilities

By Max W. Ball

This address delivered at the Annual Meeting of the Metallurgical and Mining Institute (Transactions, Volume XLIV, 1941, pp. 145-153) in March, 1941, at Montreal, though not dealing with Hydro or other matters directly related to the electrical industry, is reproduced herein on account of its particular significance during these war times, which *The Bulletin* believes will be appreciated by its readers.—EDITOR.

YOU have been kind enough to ask me to speak to you on "The War and Anglo-American Relations." A speaker always takes the liberty of putting his own interpretation on the scope of his subject. I am going to exercise that privilege, and try to look back over a generation of Anglo-American relationships and forward beyond the present war. I should like particularly to consider responsibilities as well as relationships. A more accurate caption for what I am going to say would be "Anglo-American Responsibilities."

THE WAR WILL BE WON

I am assuming that sooner or later we shall win this war. History and economics point to the same conclusion, that Germany has attempted the impossible and that the seeds of defeat are already sown. As to one economic factor, I am already on public record as believing that Germany's oil supply is inadequate for the war she has launched. That opinion is unchanged. Aside from such tangible factors, moreover, I am convinced that the spirit of freedom is unquenchable, and that no combination of powers will be able to rout it from the British Commonwealth of Nations and the United States. Stronger even than this conviction is my faith in a God who will not suffer the defeat of man's aspiration to be master of his own soul. I am sure that all of you share that faith, and that we need not argue it. We can start with the assumption that the war will end in victory.

The subject we are to consider, then, is the relationship of the English-thinking peoples during the conflict, and their joint responsibilities in the difficult days that will follow it.

A CANADIAN-AMERICAN

No talk on such a subject is worth listening to unless the audience knows the background and fundamental beliefs of the speaker. No human statement stands alone; behind and beside and within it are the ideals and the bias of the man who makes it. Because I am a stranger to most of you, I am constrained to talk about myself before I talk about more important matters. The review may be profitable, not because of the subject, but because it may illustrate the evolution of an attitude toward England.

I am an American citizen, born in the United States. All of my ancestors for from five to nine generations back were born in the United States. The most recent migrant to America came from Switzerland when Indian raids were still common in western Pennsylvania. The others were English, Scotch,

Irish and Dutch. I have never been outside North America, and never more than a mile south of the Rio Grande.

Since 1930 I have spent much of my time in Canada, and since early in 1937 I have lived in Edmonton. For several years my principal business interest has been in Canada. I have been welcomed and made to feel that I am wanted, and I feel as much at home on this side of the line as on the other. I am not a full-time Canadian, however; I maintain an office in Denver and my consulting work takes me hither and yon throughout the United States. My son is attending the Colorado School of Mines and says "skedule" and "ze"; my daughter is attending the University of Alberta and says "shedule" and "zed." I am probably as complete a Canadian-American hybrid as can be found.

What, then, about my attitude toward things British? Like most Americans of my years, I was taught in school books to think of the British as tyrants, the enemy who tried to keep the American colonies in subjection and against whom they had to fight to gain freedom and self-government. No one told us in those days that the English had for centuries been climbing the ladder of popular government, even though they had not yet reached the height of extending it to their colonies. No one told us that while we were fighting our Revolution the English people were themselves waging a valiant struggle against the abuse of royal prerogatives. All we were taught was that the English had been our oppressors and that we had been compelled to win our liberties from them by force of arms. When we played our boyhood games of war and glory the enemy was always the British or the Indians, the Redcoats or the Redskins; it didn't much matter which; they were equally bad.

The Spanish-American War and the Pax Britannica

Then something happened. When I was a lad just beginning to think for myself, the United States fought its war with Spain, a war fought for the freedom of an oppressed people outside our boundaries. Like most Americans, young or old, I was shocked by the fact that the countries of continental Europe, almost without exception, sided with Spain. Even such a cradle of liberty as Switzerland was strongly pro-Spanish. I used to be astounded at the letters my sister received from a chum whose father was American Consul in Zurich. But England! Ah, England was different. England recognized that the United States was fighting for something in which Englishmen believed, in the right of man to determine his own government. England gave the United States something akin to what the United States is now giving England—every aid short of war. From that day forward, to me and to millions of other Americans, England was no longer the ancient enemy of our liberties; she was the friend of liberty and the friend of the United States.

Do you remember the discussion that ran through the States after the Spanish-American war, advocating an Anglo-American union; not necessarily a political union, but a union of collaboration and co-operation? Perhaps it was discussed in Britain and Canada, too; I wouldn't know. I was a boy,

with all of a boy's enthusiasm. I became a devotee of the idea. I still am.

Then came the long years during which peace became a normal condition in most of the civilized world, and Anglo-American friendship came to be taken as a matter of course. I studied a bit of world history during those years, and I needed to be no brilliant student to recognize that the peace was a "Pax Britannica," that respect for the might of England was the major factor in preventing one power from attempting the conquest of another, and that the spectre of what happened to Napoleon was a constant reminder of what would happen to anyone who might again attempt to rule the world by force.

THE WORLD WAR AND THE LEAGUE OF NATIONS

Then came the World War. A man with a Napoleonic complex decided that Britain had lost both her idealism and her political judgment and would stand aside while he made himself master of Europe and perhaps of much of Asia. Millions of Americans believed we should enter the war at once. I was one of them. When the then President said, "We are not concerned with the obscure sources from which it has burst forth," we felt enraged and degraded. We felt, as did Theodore Roosevelt, that the sources were neither obscure nor foreign to us; that in a conflict between freedom and conquest we belonged on the battlefield fighting for freedom. I am convinced that if Theodore Roosevelt had been President, as but for a turn of politics he might have been, the United States would have been in the war from the beginning, whole-heartedly, with no more dissent than there was when the country finally went in three years later. When the President of the United States tells the country for three years that a certain war is no concern of theirs, some people will come to believe it, and will continue to believe it after the President has changed his mind. The enthusiasm with which the American people threw themselves into the war when President Wilson finally said the word showed that many of them had thought we should be in it all along.

And then the peace, and the refusal of the United States to join the League of Nations. It is too long a story to review now, but I stand here and tell you that on Armistice Day and for months thereafter most Americans favoured the idea of a League and of full American participation in it. What happened that kept the United States out? Chiefly two things: First, Woodrow Wilson had fought the war as though it were not a war of the American people, but a war of the Democratic party. He handled the peace the same way. The commission that he took to Paris was a Democratic commission; not a Republican was on it, not even the ranking Republican member of the Committee on Foreign Relations of the United States Senate. The League, God forgive us, became a partisan issue —at a time when the United States was swinging sharply toward Republican normalcy.

The second thing that killed American participation is now represented by the Statute of Westminster. You, yourselves, have taken some time to change your concept from a British Empire to a British Commonwealth of

Nations. It is surprising that after the war, when the concept was new to you, the average American did not grasp it? To be candid, he does not grasp it yet? He still thinks of the British Empire as a unit. So, most of the time, do you. You can imagine the American's reaction, then, to a League of Nations in which the United States would have one vote, the British Empire five. The concept later embodied in the Statute of Westminster may have made Canada, Australia, New Zealand, and South Africa free and independent nations, but it helped to kill American participation in the League of Nations. Not all the maladroitness in the handling of the League's promotion was concentrated on the banks of the Potomac.

Even so, the League was not rejected by the American people. They never had a chance to vote on it apart from other and wholly unrelated issues. President Wilson made it an issue in the campaign of 1920 to choose his successor, but it was only a single plank in the platform of his party. The other planks concerned domestic matters, and were not popular. Most Americans, forced to choose between membership in the League and economic policies they feared would be disastrous, forgot the League and voted for economic soundness. I know how they felt, for I was one of them. A strong believer in the League and in American membership in it, I nevertheless voted against the League-sponsoring party in that election. You can see, then, how far the American people were from actually rejecting membership in the League.

The Tragic Years of Peace

So we come to more recent times. I wish we might pass over the years between the Treaty of Versailles and the invasion of Poland. They contain so many mistakes! They are the tragic years. There are those who will say that the only tragic years are the years of battle. I tell you that the years of battle, with all their bloodshed, are the years of courage and sacrifice, of the upsurge of determination that right shall not be banished from the earth. The tragic years are the years of sloth and cynicism, when men come to prize life and ease above right and liberty. Yes, these have been the tragic years, the years when the good wrought from the last war could have been preserved and the evils of the present one avoided, and they were not.

What happened to us during those years? It seems to me that we succumbed to certain dangers inherent in democracy. Like any other product of man's thinking and evolution, democracy has its dangers. Let us examine some of them.

The Materialistic Doctrine of Pacifism

The first I would name is pacifism. It is an especial danger because it wears a semblance of the ideal of democracy itself. Democracy exalts man, the individual. It proclaims his right to life, liberty, and the pursuit of happiness. Of these three things, life is tangible, material; liberty and the pursuit of happiness are intangibles, things of the spirit. Pacifism seizes on the tangible thing and exalts it as the whole. It makes man's life and man's right to it the sole thing of importance. In pacifist philosophy he should never

be called upon to sacrifice or endanger his life for the sake of the spiritual rights such as liberty and the pursuit of happiness, either his own or those of others. I submit that never in all history has there been a more materialistic philosophy, a doctrine that more clearly exalts bodily well-being above spiritual values. Yet this doctrine, so definitely the negative of Christ's philosophy that "Whosoever would save his life must lose it," lives intimately among us in the garments of Christian idealism, the pet of our women's clubs, the favourite of our schools, and the darling of our churches.

We need not theorize about its dangers. We have only to look back over the past ten years. Because pacifism permeated our thinking and war was considered the only evil in God's sight, the Manchurians and millions of Chinese are slaves to the Japanese, the Ethiopians and the Albanians are slaves to the Italians, and the Czechs, Slovaks, Poles, Danes, Norwegians, Dutch, Belgians, Rumanians, Bulgarians and French are slaves to the Germans.

The pity of it is that probably war would not have been necessary to prevent all this if our horror of war had not been so great. The watchman seldom has to shoot to prevent the store he guards from being robbed. He needs merely to be armed and prepared to shoot if necessary. If we, and by "we" I mean the believers in democracy, had not told ourselves we must never under any circumstances go to war, and in consequence let ourselves become too weak to fight, we should not have needed to fight. A strongly-armed England, or a strongly-armed United States, ready to use her strength, could have kept Japan out of Manchuria without doing battle. Italy would not have attacked Ethiopia if the British had been strong instead of weak. Germany would still be within her 1930 boundaries, with or without Hitler, if Britain had not permitted her to re-arm and to occupy the Rhineland. No war would have been necessary; all that was needed was the willingness to fight. Hitler would not have given battle; he had nothing to battle with.

We gain nothing by blaming the government then in power. The governments of free peoples, and in fact of all peoples, come pretty close to representing the ideals and desires of the governed. The pacifist government of Britain when Hitler invaded the Rhineland was spirit of our spirit. We all feared war so much that we were unwilling to risk a little war to make a big one impossible. We might have taken to heart a sentence from Machiavelli, "Never permit an evil in order to avoid a war, for the war will come and you will be in poorer case to maintain it." But such common sense was out of date in those pacifistic years, and the evil was permitted, the war came, and we were in sad case to maintain it.

The Sentimental Doctrine of Universal Self-Government

The second danger of democracy represents a different type of slipshod sentimentality. We assume that because we are capable of governing ourselves after a fashion and of respecting the rights of our neighbours, all men have the same desire and ability. Nothing could be more false or more dangerous. The art of self-government is not an inherent gift; it is the product

of long and painful practice. Those of us who speak the English tongue have taken more than six centuries to achieve it in its present imperfect state. Turn back the pages of history and see how slow our progress has been, how many times we have taken the wrong turn, how often the ideal has seemed to be lost, how hardly won each step has been. Self-government calls for self-discipline, a spirit of fair play, a willingness to accept the will of the majority, no matter how much we may dislike it. Is there any way in which these things can be learned except through generations spent in the hard school of experience?

Look over the world and count the peoples who have demonstrated their ability to do it. You can count them on the fingers of a single hand: The English-speaking peoples, the Scandinavian peoples through whom the germ of the idea came to England, the Swiss, the Dutch, and the Belgians. That's all. The Czechs and Slovaks made a start, but only a start, in the twenty years they had to try. The Poles stumbled before they got under way. The French? Not yet, though no nation, perhaps, has stronger aspirations. The Third Republic lasted a little more than seventy years and in that time had something more than sixty-five governments. Such a history does not indicate that the French have yet achieved the political stability required for self-government.

Why is this easy-going belief in self-government as an inherent gift a danger to democracy? Because it leads the democracies to treat other peoples as though they had the same aspirations and ideals. It is leading the United States and Britain toward two steps that will almost certainly cause suffering and bloodshed to those supposed to benefit—the granting of independence to the Philippines and dominion status to India. After the last war it led to something far more dangerous than India or the Philippines can be; it led us to think that the Germans, the Austrians, the Hungarians, and the rest of the world had the same desire and capacity for governing themselves, and for living at peace with their neighbours, that we have, and so it led us directly to the present war. It is a mistake we must not make again. Somehow we shall have to devise a system that will give other peoples a chance to learn the arts of self-government and international honour, and to reap the benefits when they have earned them, but that will guard against their abusing their privileges meanwhile.

The Cynical Doctrine of Self-Derogation

These two dangers, pacifism and sentimentality toward other peoples, find a common expression in a third danger, the derogation of what we have done when the doing of it is over. We have a positive and malign genius for it. The word for it is cynicism. Twenty-odd years ago we fought a righteous war and made a reasonably just peace, but have we told our children so? You know we have not. It has been smart to be cynical about our purposes and our accomplishments. What have our books, our magazines, our teachers, and our preachers been saying for the past two decades? Mainly that the World War was a brutal war, fought by England to prevent Germany from attaining

economic equality; that England drew the United States into it to pull her own chestnuts out of the fire; that, whatever its cause, it was a failure and should not have been fought because it failed to establish a perfect world order and a permanent world peace; that the peace treaty was an iniquitous business that wreaked an unjust vengeance and that unwarrantably humiliated a people as proud and deserving as ourselves. Have you read the histories taught in your high schools up almost to today? I looked through those my daughter studied last year, in a Canadian high school, mind you. I found little to suggest that the Allies fought the World War in defence of the sacredness of treaties against conquest and oppression; much to suggest that they were actuated by "power politics" and envious economics. I found that the Peace of Versailles was a vengeful peace, unduly hard on Germany, that not only caused but justified the rise of Hitler.

If such things have been taught in Canada, you may be sure they have been taught in the United States. Is it any wonder that, after twenty years of such teaching, the United States should not be in this war? Considering what we have permitted them to be taught, we have every reason to be surprised that the youth of Canada have responded so nobly to freedom's present cry of distress. We may recriminate all we like, but if any of us, on either side of the line, go reluctantly about our duty of defending liberty, we have only ourselves to blame for letting false and cynical teaching mould the minds of our people through the tragic years behind us.

Present Anglo-American Unity

Well, those blind, blundering tragic years are gone. What of the present and the future?

As to the present, I do not need to tell you that the people of the United States hate Hitler, his associates, and all they stand for as bitterly as do the people of Canada. The lease-lend bill represents far more than a new statute on the books; it represents the grim will and determination of the people.

Do not be unduly disturbed by the thirty-one votes against it in the Senate. Not all were hostile votes. Some, of course, were cast by isolationists, who somehow manage to make a great deal of noise while their heads are buried in the sand. Some were cast by peace-at-any-pricers, a few by men in whom the hostility of 1776 still lingers, some by men who cannot bring themselves to vote with Roosevelt even when they feel that he is right, but some were cast by ardent and loyal friends of Britain. That surprises you, and calls for a word of explanation.

The lease-lend bill gives the President power to give or withhold aid when, to whom, and from whom he chooses. To the extent that American aid is essential in the war, it makes him the arbiter of its destinies. He could conceivably say to Britain or to Greece or to Canada, "Unless you thus and thus conduct the war," or "unless you promise thus and thus to make peace," our aid will be withheld. There are sincere Americans who feel that such power should not lie with the head of a non-belligerent country, but should rest in those who are giving their blood and sweat to the fight; that Joab in the field and not David in Jerusalem

should decide whom to place in the forefront of the hottest battle, and when and for what cause to retire from the attack.

Whether they are right or wrong is a question not before us here. Right or wrong, they are lost in the multitude of Americans who are less concerned with such fears than with quick, effective, and overwhelming aid. The voice of that multitude resounds in the lease-lend bill, and their will will be felt in the aid that follows.

Whether the United States will enter the war as a belligerent, and if so when, I know no more than you, but one great fact stands out: Now, already, today, the English-thinking peoples are united in a common cause.

The Enforcement of Peace

As to the future, the thing that concerns me most is how we are going to meet our joint responsibilities during the post-war years. On us, the English-thinking peoples, will rest the chief burden of planning and maintaining the post-war world. How shall we plan and maintain it? No human mind can foresee what will need to be done, or how it should be done, but I think we can agree on a few fundamentals.

We should have learned by now that no world order will function safely on international honour alone; not until all the peoples involved have attained, through generations of practice, to common standards of self-government and international honesty. Until that time, the world will need a police force powerful enough to prevent international robbery. Nations are much like individuals. So long as there are criminals and potential criminals there must be police. When private crime ceases and police are no longer needed, then international peace may maintain itself on an honour basis. Meanwhile peace, like personal honesty, must be enforced. Who, then, shall enforce it?

Anglo-American Enforcement

From a coldly practical standpoint, the safest and most pleasant world to live in for the next fifty years would be one in which peace was enforced jointly by the English-speaking nations. The British and Americans are not saints nor are they above selfishness, and there would be deviations from strict fairness and justice, but on the whole the policing would be honest, fair, and effective. The mere suggestion, however, would throw every non-English patriot and most English-speaking idealists into spasms. It would be made to sound like tyranny of the worst sort. The idea is so coldly practical as to be wholly impractical.

It is not impossible, however, to conceive of some sort of association to which all people who have shown themselves capable of self-government and who have a reasonably long record of international honesty would be admitted on an equal footing, each having a voice in its affairs and contributing to its joint police force—an association to which other nations might be admitted if and when they have given evidence of the necessary qualifications. Such an association could be set up as soon as peace is achieved. The requisites for its success would be the self-discipline and honour necessary for any form of self-government, plus the adequacy of its police force for any situation and an unhesitating willingness to use it, and a realistic attitude with respect to further admissions. If paci-

fistic philosophy should weaken its power or its will to use that power, or if sentimentality should lead it to open its gates to a preponderance of unfit, the end would be chaos.

Please do not think I am trying to lay down a plan for a post-war system. I have little faith in planned economics or planned world orders. I believe success in social and political systems comes only through evolution, through trial, error, and never-ending amendment. My only object in what I have said is to emphasize that after the war there will be a peace to make and enforce, that the responsibility for making and enforcing it will fall chiefly on the English-thinking nations, and that only as they see together, think together, and act together can lasting peace and justice be achieved.

The Pitfalls and Requisites of Peace

Can we do it and avoid the errors of the past? Let us study again the fumbled years since the Armistice and the pitfalls into which we fell.

We must avoid, if we would save the world, the recriminations that rubbed the sores of the last war. This time let no flamboyant American cry, "We won the war," and let no impatient Canadian answer, "Why didn't you come in before the war was over?" However much we may argue, as argue we shall, over tariffs, trade rivalries and such things, we must hold fast to the comradeship that a common enemy and a common danger have given us.

Britain, let us speak frankly, must avoid even the appearance of acquisitiveness. At the end of the last war there were those who said, with the appearance rather than the substance to justify them, that Great Britain had fought a selfish, not an idealistic war, because she emerged from it with enlarged territories. This time, if Anglo-American unity of sentiment is to be preserved, she must so conduct the peace that no one may accuse her of having profited.

The United States, for her part, must abandon all thought of isolation. It may be hard for you, Canadians, to realize how difficult a task this may be. As citizens of a world-wide Empire you have always been world-minded. The tradition of the United States for a hundred and fifty years has been one of isolation. Because of her vast area and her self-contained economy she has not needed to look to world affairs. Millions of her people have never seen an ocean or an ocean-going ship. For generations her safety and her welfare lay in Washington's admonition to "avoid entangling alliances." She finds it hard to realize how great she has grown and how small the world has shrunk. She is not yet fully awake to the responsibility that her wealth and her strength have thrust upon her. She still wonders whether she cannot live in a world apart, with no participation in the world outside her borders. Yet awaken she must, and live fully in the larger world in which she finds herself, and shoulder her full share of its responsibilities, if she would escape the disorder and turmoil of a world that cannot be organized without her.

Lastly, in the years that lie ahead, we must avoid the stumbling weaknesses of the years behind, pacifism, the sentimental assumption that all people share our aspirations and have

learned our lessons of self-discipline, and the cynical decrying of our own ideals and purposes.

These are the requisites for a future of peace and safety. Whatever world system or arrangement is based on them may not be perfect, but it will have a foundation permitting it to grow toward perfection. No system or organization that is based on less will live long enough to grow.

God Grant Us Unity

And these, mark you, are the requisites of strength, a strength that, when this war is over, will remain only to the English-thinking nations in unison. No one of them, Great Britain, Canada, Australia, or the United States, will alone have the strength for the task. Peace, no less than victory, will require all that we can give in a common cause.

Thus, inevitably, we come to our final conclusion: If the nations that speak the English tongue continue after the war to work in harmony for their common ideals, the future, despite all the waste and woe of the present, may well be a happy one. If, on the other hand, Great Britain should swing toward a policy of acquisition or the United States return to a policy of isolation, or if pacifism or sentimental idealization of other peoples or cynicism toward their own ideals should again weaken their moral fibre, I shudder for the world in which our children and our grandchildren may have to live.

Let us pray God, then, as we have never prayed before, that not death nor life nor principalities nor powers nor things present nor things to come nor height nor depth nor any other creature may ever again separate the spirits of the peoples who revere the English tradition.

T. C. Savage, Waterford, Retires

The resignation of Thomas C. Savage, chairman of the Waterford Hydro Commission, on July 1st, removed one of the older and well known members of our convention from further participation in Hydro affairs.

He had been a member of his local commission since 1918 and chairman continuously since 1922 to the time of his resignation. He was reeve of Waterford in 1916 and has been postmaster since 1917. He has always been active in local municipal affairs, and is widely known for his keen sportsmanship, particularly as a lawn bowler, hunter, and fisherman.

Mr. Savage suffered from ill health early this summer, and though he has partially recovered, on the advice of his physician he retired from all public duties except that of postmaster.

As a token of good fellowship and appreciation of his many years of faithful and efficient service members of village council and the Hydro commission called at his home recently and presented him with an easy chair and ottoman. Mrs. Savage was also the recipient of a suitable present.

Ex-Warden Wilton E. Honey, succeeds Mr. Savage as Hydro commissioner, with Jas. R. Forbes, as chairman.

Measurement and Control of Conductor Vibration

By Gordon B. Tebo, Testing Engineer, H.E.P.C. of Ontario

THE occurrence of fatigue failures in conductors, and the more rapid deterioration observed with increase of span length and tension, disclosed a serious hazard in existing transmission lines. Pioneer investigations of Relf and Ower[1], Varney[2] and others showed that the fatigue failures were due to vibration of conductors in steady winds of relatively low velocity, and that the vibration was excited by wind eddies which exert alternating vertical forces on the conductor.

Many subsequent studies have been directed toward prevention of vibration fatigue in conductors and in these numerous investigations there naturally were developed many devices for vibration control. Unfortunately no method for comparing their affectiveness has been generally accepted and as a result, widely different devices have been extensively applied.

Installations of armour rods, festoons, dampers, special clamps, and other protective devices have been made under quite different conditions of terrain, conductor size, tension and span length. Reports of subsequent tests or inspections were often incomplete, and although reports of operating experience indicated satisfactory performance for some of the devices, no definite opinion could be formed of their comparative effectiveness.

Paper presented to the American Institute of Electrical Engineers at Toronto, June 19, 1941.

Preliminary Studies

The Hydro-Electric Power Commission of Ontario, faced with this difficulty in adopting measures for protection of existing and proposed lines, commenced a program of vibration research. Some phases of this program have been described previously,[3 4 5] in which analyses have been made of the effect of conductor shapes, stress distribution and energy loss in conductors due to travelling waves, and fatigue characteristics of steel wires.

Preliminary studies indicated the desirability of testing vibration-suppressing devices on full-size wind-excited spans, because no other method took full account of the complex relations between the wind eddies and conductor. In field tests of this nature it was recognized that the vibration records should reliably indicate the effectiveness of the various devices tested, in reducing or eliminating vibration fatigue. A survey was made to determine the limitations of available recording apparatus for this purpose.

Recording Apparatus Available

Clock-driven live-line recorders of the Zenith and Servis type[6] indicate amplitude approximately, but give no indication of frequency. These may be supplemented by cycle counters of the Jaquet type,[7] which register the total number of vibration cycles above a fixed amplitude. From the combined records, it is possible to estimate the approximate amplitude, number of

hours vibration per day and average frequency.

More complex recording mechanisms, using motor driven wax charts[6] or oscillographs[8] have been described. These measure the amplitude, frequency, and wave shape at a point on the conductor two feet or more from the suspension clamp, and thus indicate the effectiveness of dampers in suppressing vibration. They do not, however, provide a measure of the stress-relieving properties of special clamps or conductor reinforcements.

Two methods of recording the actual bending in a conductor adjacent to a suspension clamp, have been described. One[6] uses a mechanical linkage, connected by waxed strings to the conductor on opposite sides of the suspension clamp. Another[9] employs an optical arrangement to record on photographic film, the motion of the vibrating conductor relative to the suspension clamp.

A carbon-pack type of curvature recorder[4] has been found useful for oscillographic recording of travelling waves in conductors, and for recording curvatures due to aeolian vibration. However, its tendency to change calibration when left unattended, made it unsuitable for continuous vibration recording.

Development of Recording Equipment

None of the devices available appeared entirely satisfactory for the purpose of this investigation. In the development of new equipment for recording conductor vibration, the following requirements were recognized:

1. Because all fatigue breaks occur within an inch of suspension or strain clamps, knowledge of stress conditions in that region was considered essential.
2. No strain gauge was available to measure stresses in the individual strands under field conditions. A satisfactory alternative appeared to be the measurement of conductor curvature adjacent to the clamp. This could be accomplished by measuring the deflection of the conductor, relative to the clamp.
3. Deflections of the conductor occurring within an inch of the clamp, even under severe vibration, amount to only a few thousandths of an inch. One essential of the recording device was therefore a sensitivity of 0.0001 inch.
4. Ability to record vibration on live lines was not considered essential because adequate test spans were available to simulate any existing or proposed construction. Tests could be made on new lines during construction, and system conditions were such that many existing lines could be interrupted for suitable test periods.
5. Other desirable characteristics of the measuring device were the ability to record deflections at all frequencies up to 60 cycles per second, stable calibration, lightness and ruggedness.

A magnetic method for measurement of small mechanical movements, described by Mershon[10, 11] and others, appeared applicable to this problem. This type of measuring device uses an iron magnetic circuit, excited at a relatively high frequency, usually between 500 to 2000 cycles per second. The length of a small gap in the magnetic

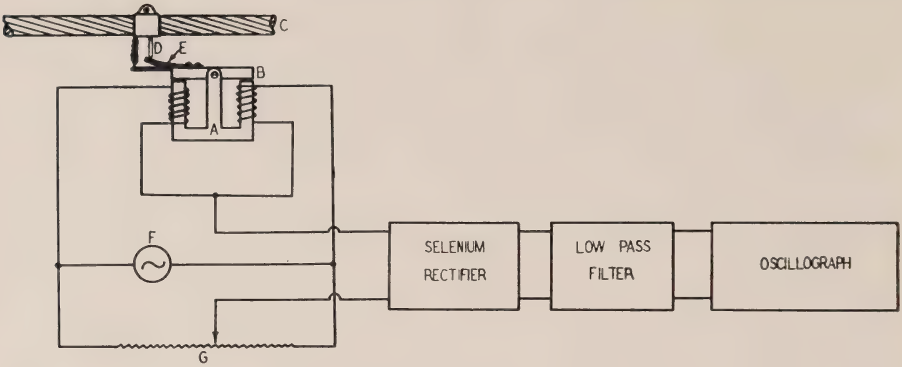


Fig. 1—Schematic diagram of vibration recorder.
A—Core and balanced coils to be mounted on suspension clamp.
B—Pivoted armature, driven by conductor C through post D.
E—Bimetal strip to compensate for changes in conductor sag.
F—Supply voltage, 500 cycles per second.

circuit is altered by the motion to be recorded. The resulting change in impedance of the exciting coil may be made to produce an electrical output proportional to the motion.

Fig. 1 shows some details of the device developed for recording conductor vibration. Use of the double magnetic circuit shown, resulted in linear calibration over practically the whole travel of the armature. Effect of the non-linear relation of resistance to current in the selenium rectifier at low current was avoided by using a suitable bias current, obtained by initially unbalancing the rheostat (G). Sensitivity of the recording elements could be varied to provide ratios of oscillograph deflection to conductor deflection of any value between 10 and 1000.

Provision was made for an over-all calibration after the magnetic device had been installed on the suspension clamp as shown in Fig. 2. For this purpose a dial micrometer was temporarily clamped to the device and used to indicate displacement of the armature produced by lifting or depressing the conductor. Correlation of micrometer readings with oscillograph deflections provided a calibration which was found to be reliable, and accurate to plus or minus five per cent on a one-inch oscillograph deflection. The static calibration values were found to apply, without correction, for the range of frequencies encountered in power conductor vibration. Although measurements could be made of conductor deflections to within 0.1 inch of a clamp, it was customary in field tests to record conductor motion about three inches from suspension clamps.

Five such units, in conjunction with a multiple filter and a six-element oscillograph, provided continuous records of conductor vibration on 5 spans, the sixth oscillograph element being used for a timing wave. Fig. 3 shows the recording equipment in portable form as used on high voltage lines during construction.

Provision was made to run the oscillograph film at a speed of two inches

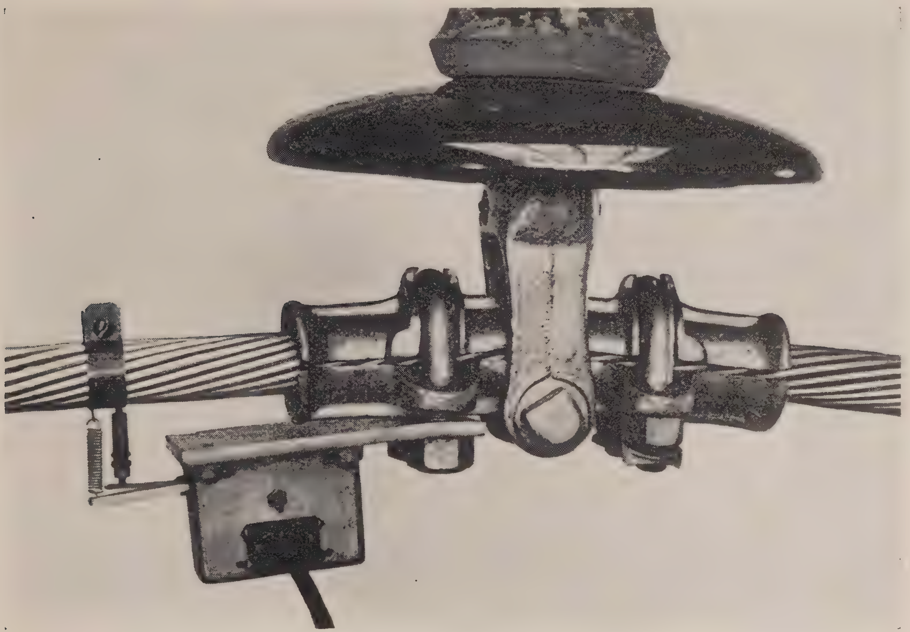


Fig. 2—Magnetic device for recording deflections of conductor relative to suspension clamp.

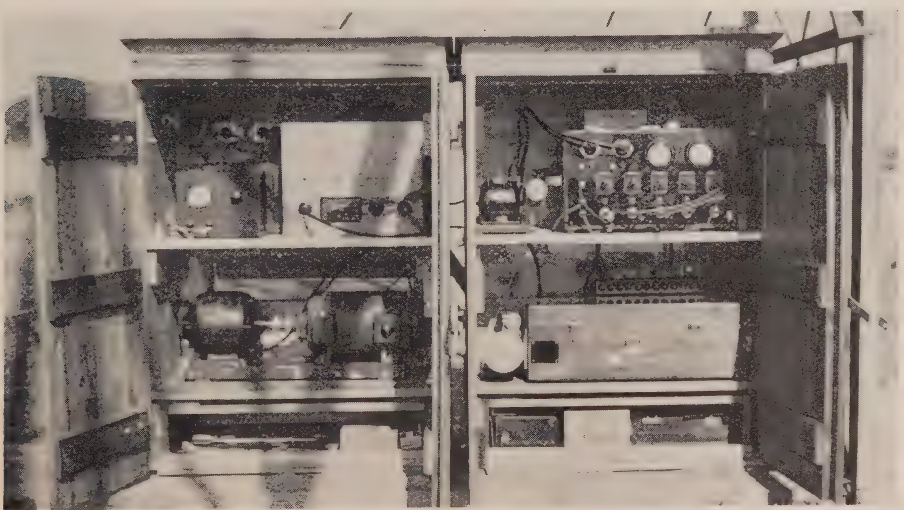


Fig. 3—Automatic equipment for recording vibration on five conductors.

Left—Timing device and 500 cycle generator.

Right—Five-unit control (top) and six-element oscillograph.

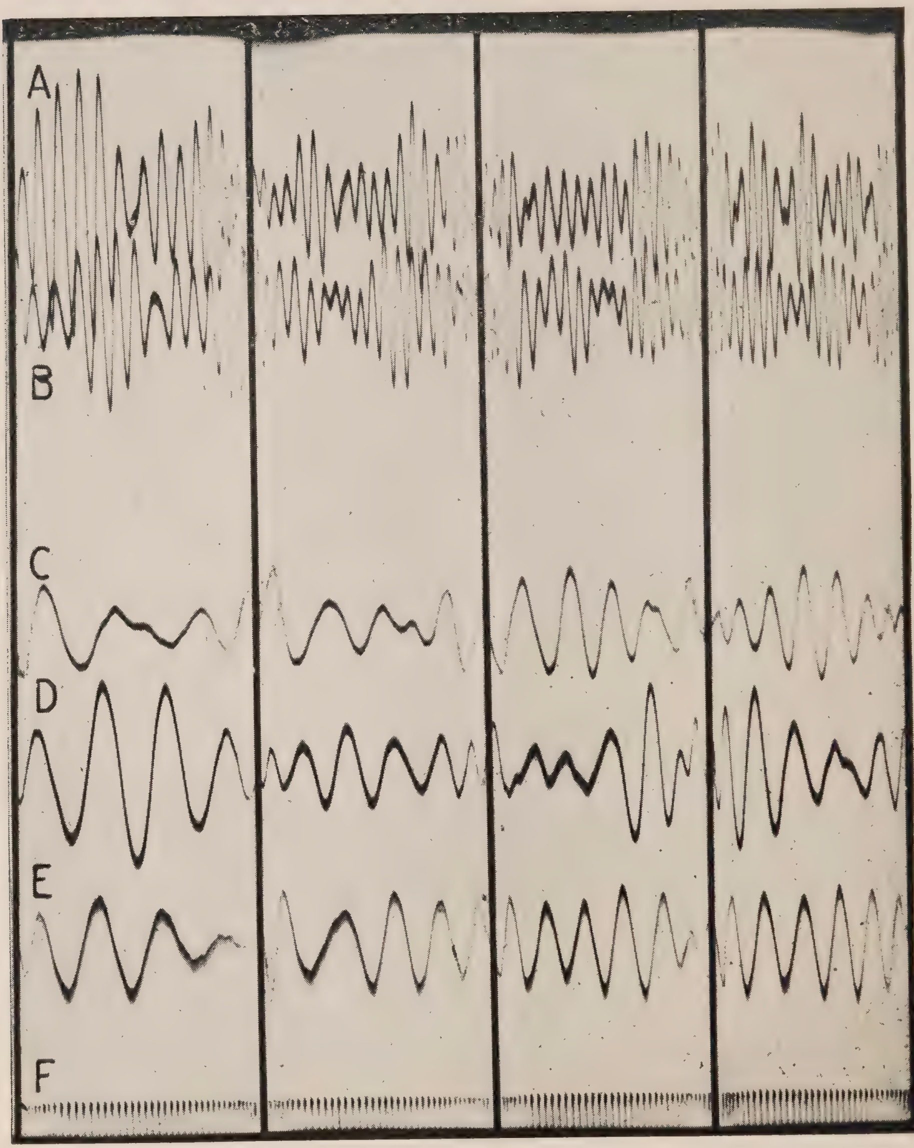


Fig. 4—Typical vibration records on 220 kv. line.
A and B—Skywires 3/8 inch steel.
C, D and E—Power conductors.
795,000 cir. mil a.c.s.r., Drake.
F—Timing wave, 60 cycles per second.

per hour, obtaining a continuous record of amplitude, and once every half hour, to increase film speed momentarily to record amplitude, frequency and wave shape. The high speed records were found to provide the more useful infor-

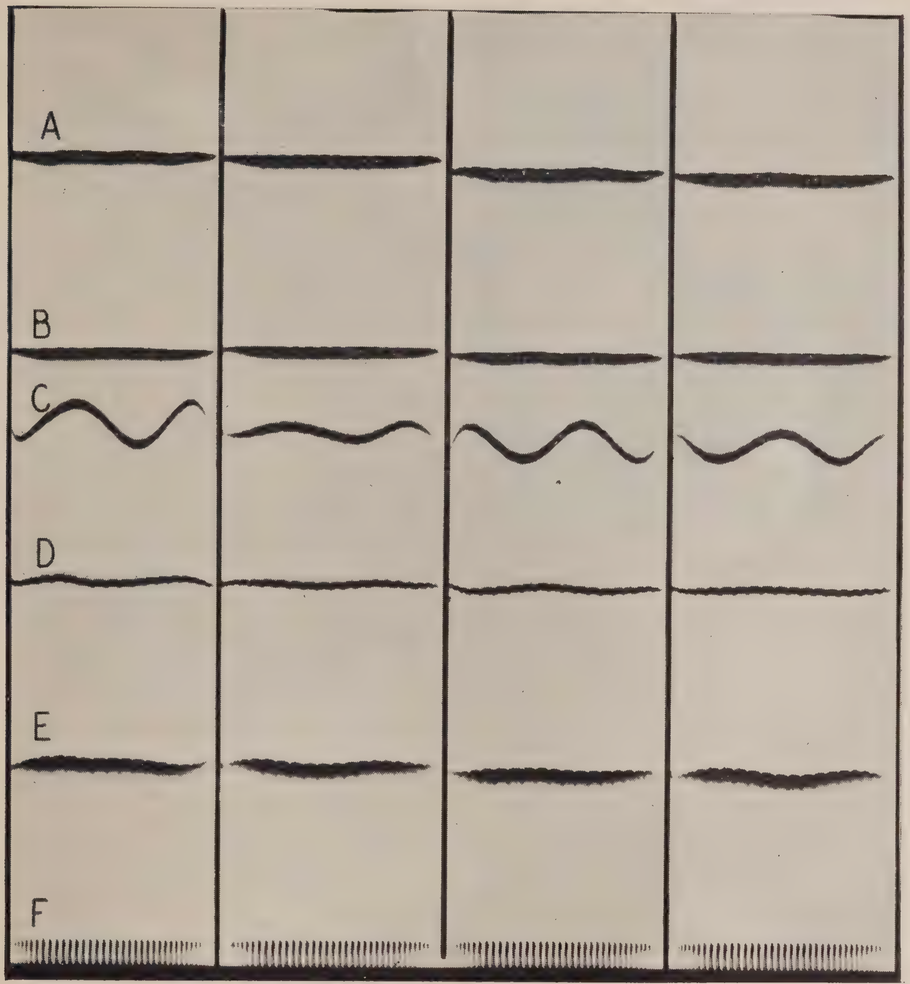


Fig. 5—Typical damped span vibration records.
A and B—Skywires with 25-foot festoons of 3/8 inch steel.
C—North 795,000 cir. mil a.c.s.r. with 2 Stockbridge dampers per span.
D and E—Centre and south power conductors with 2 Torsional dampers per span.
F—Timing wave, 60 cycles per second.

mation, and in later tests, the low speed records were discontinued. Fig. 4 shows a typical record obtained on the two skywires and three power conductors of a 220 kv. line before dampers had been erected. Fig. 5 shows a similar record after the installation of dampers on the power conductors and festoons on the steel skywires.

Anemometer Records

The linear relation of vibration frequency to wind velocity, determined by Relf and Ower,[1] has been generally accepted. Nevertheless, it was thought

Fig. 6—Anemometer for recording instantaneous values of low velocity winds.

desirable to obtain field records of instantaneous wind velocity, since most of the values reported were obtained by rotating-cup anemometers which are unable to record rapid fluctuations in velocity or direction. Following, in some respects, the designs of Sherlock and Stout,[12] an anemometer was developed for recording instantaneous values of wind velocity and direction on the same film as the vibration records. Fig. 6 shows the anemometer, which was capable of following rapid fluctuations of wind velocity and direction and had a linear calibration over a range of 3 to 15 miles per hour.

Correlation of the anemometer records with those of conductor vibration have confirmed the generally accepted ideas that most vigorous vibration occurs in steady winds at velocities of two to ten miles per hour directly across the line; that conductors vibrate in variable winds, but at lower amplitudes; and that wind gusts produce no appreciable vertical motion of the conductor. Vibration frequency was occasionally found to deviate rather widely from the accepted relation to wind velocity. However, it was concluded that wind velocity records, even of the instantaneous type, added little to the information available from the vibration records.

Test Spans

A number of towers, providing a choice of span lengths from 300 to 1400 feet were available in a level district where aeolian vibration occurs on undamped spans about 60 per cent of the time. By erecting suitable conductors and accessories in these spans, full scale models of existing or proposed line construction could be provided.

Comparison of vibration records obtained on the test spans with those obtained on similar spans of new lines being constructed, showed close agreement in maximum amplitude, range of frequencies and number of cycles per day. It was found also that predictions of the performance of vibration suppression devices based on records in the test spans were confirmed by subsequent tests on actual lines.

Test spans were also provided for making endurance tests on 150-foot lengths of cable, strung at normal tension between concrete piers. At one end the cable was supported in a rigid clamp; at the other end, a motor drive was connected to produce vibration in the span at the desired frequency and amplitude.

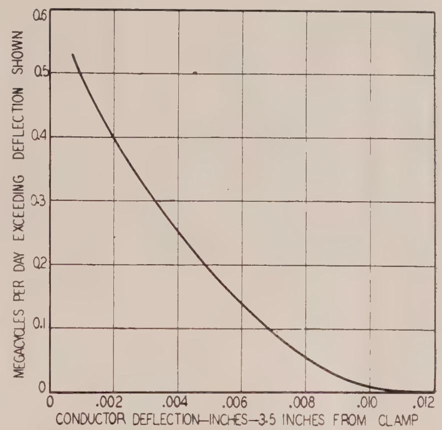
Test Procedure

Under normal wind conditions at the test spans, it was found that vibration records covering a period of two weeks

were sufficient to establish the performance of any span. During this period, the full range of effective wind velocities, vibration frequencies and amplitudes were encountered, and additional records did not affect the average results appreciably. In testing damped spans, simultaneous records on undamped spans were usually obtained for comparison. It was found desirable that such undamped conductors be supported on separate towers to prevent excitation of the damped spans by tower vibration.

In analyzing the field data, certain assumptions were made to simplify the calculations and to permit presentation of the results in graphical form. For any one test, at least 500 momentary records of amplitude and frequency, taken one-half hour apart, were analyzed. Each half-hourly record, although it covered a time of less than one second, usually showed cycles of varying amplitude. Only the maximum amplitude was measured, and this was assumed to persist for the entire half-hour period. The frequency indicated was also assumed to persist for the half-hour period. Use of the maximum amplitude shown in each record introduces a conservative factor in the analysis, but this same factor would occur in analyzing any low-speed vibration record, which can register only the maximum values of quickly changing amplitudes.

Analyses of the records may be plotted to show the relations of amplitude, frequency, number of cycles per day, or number of hours vibration per day. The most useful types of graphs were found to be those shown in Fig. 7. The frequency range determined for



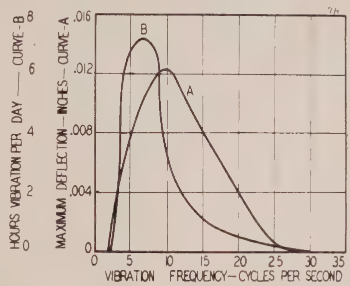


Fig. 7—Vibration characteristics of 795,000 cir. mil a.c.s.r. Drake in 1150 foot spans at 5500 pounds tension. No dampers. Suspension clamp as shown in Fig. 2.

any particular construction is essential information for the design of suitable dampers. The number of cycles per day at various deflections may be correlated directly with fatigue tests to determine the probable life of the conductor. It is not possible in fatigue tests to duplicate the varying amplitudes and frequencies which occur on field spans, but by choosing the frequency at which maximum stresses occur in the field, and by measurement of conductor deflection relative to the supporting clamp with the same instrument used to record field vibration,

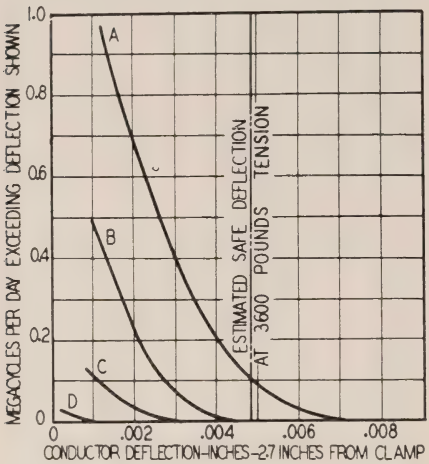


Fig. 8—Effect of span length and tension on vibration of 477,000 cir. mil a.c.s.r.

A—1400-foot span at 3600 pounds tension.

B—650-foot span at 3600 pounds tension.

C—650-foot span at 1800 pounds tension.

D—Same as A with 2 dampers per span.

a satisfactory correlation may be obtained.

Effect of Span Length and Tension

In order to determine quantitatively the effect of variations in span length and tension, vibration records were obtained on three spans of 477,000 circular mil a.c.s.r. "Hawk" stranding. These spans were chosen to show the effects of fifty per cent reductions in either span length, tension or both. Fig. 8 shows the results obtained.

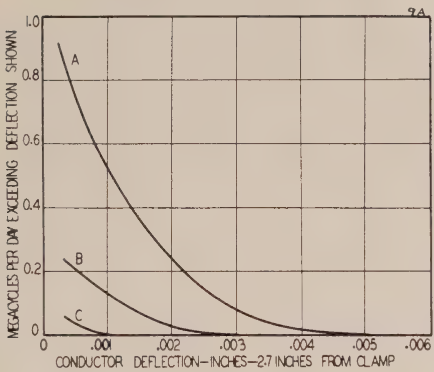
Reduction of span length only is shown to considerably reduce both the number of cycles per day and the maximum deflections. Reduction of both span length and tension further reduces the severity of vibration. The most significant fact, however, is that the installation of effective dampers on the longer span at the higher tension, provides much better suppression of vibration than can be obtained by any reasonable decrease in span length and tension.

Comparison of Loose-core Cable and A.C.S.R. of Standard Stranding

A form of cable described by Preiswerk,[13] is claimed to be vibrationless because of interference between the wind-excited outer aluminum envelope and the loose steel core. A 1000-foot length of this cable (477,000 circular mil) was erected in suspension clamps on two towers, providing a test span of 650 feet, at a tension of 2975 pounds. The ends of the cable were fitted with special strain clamps which provided the specified division of tension between the aluminum envelope and the steel core. On the same towers was erected a 477,000 circular mil a.c.s.r. "Hawk" stranding at a tension of 3600 pounds. Records of vibration were obtained on both cables, with results as shown in Fig. 9. The loose-core cable shows considerably smaller deflections, due to vibration, than the undamped standard cable and entirely eliminates vibration at frequencies above 18 cycles per second. The suppression obtained on the loose-core conductor is, however, less complete than that provided by effective dampers on the standard cable.

Comparison of Suspension Clamps

Because vibrations in adjacent spans are seldom of the same frequency, conductor motions on the two sides of a suspension clamp continually shift in phase relation. When this relation is



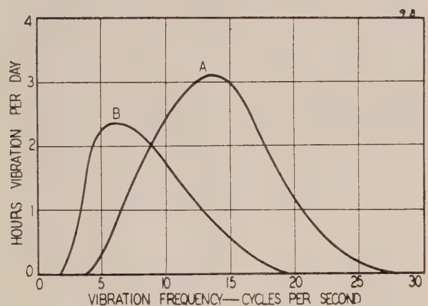


Fig. 9—Comparison of standard and loose-core a.c.s.r. in 650-foot spans.

A—477,000 cir. mil a.c.s.r. Hawk at 3600 pounds tension.

B—477,000 cir. mil loose-core cable at 2975 pounds tension.

C—Span A with 2 dampers per span.

such that conductor motion is upward (or downward) on both sides of the clamp simultaneously, it is evident that the clamp, no matter how light or well pivoted, will remain stationary, and will react on the conductor as a rigid clamp. Thus an ideal clamp with zero pivot friction and zero inertia could be expected to reduce the number of stress cycles, but not to reduce the maximum stresses. Field measurements show that available types of pivoted suspension clamps fulfil this condition. Fig. 10 is a record of deflections on opposite sides of the suspension clamp shown in Fig. 2, which shows the instantaneous conductor stresses to be equal on opposite sides of the clamp.

An attempt to overcome this limitation of the single pivoted suspension clamp resulted in development of a whiffletree clamp which consists of a bar about three feet long, supported at its centre, and carrying a suspension clamp at each end as shown in Fig. 11. A comparison of this form of clamp with the single suspension clamp is shown in Fig. 12.

The benefit of the double suspension indicated in these tests has been confirmed by field experience, in which a decided reduction in the rate of fatigue breaks has been obtained over a 10-year period of observation, in comparison with single suspensions.

New Damper Developed

In the course of these investigations, a new principle was employed in the suppression of aeolian vibrations, which resulted in development of an effective and economical damper. It is well known that when a vertical motion is imparted to a 1000-foot undamped span of power conductor, the resulting travelling wave may be clearly identified after several cycles of travel between towers. It was observed that when a torsional motion was imparted to the same span, the resulting torsional wave attenuated much more rapidly. A converter to transform the wind-imparted vertical oscillations to highly damped torsional waves is, in its simplest form, a mass clamped to the conductor with its centre of gravity horizontally displaced from the centre of the conductor.

On certain conductors, having exceptionally high torsional damping, the

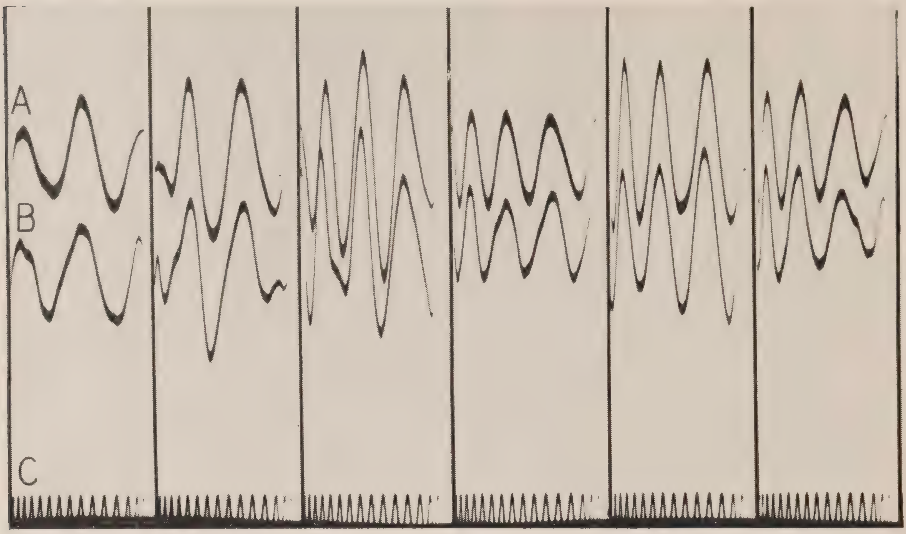


Fig. 10—Conductor deflections recorded on opposite sides of rocking-type suspension clamp.
A and B—Deflections measured 3.5 inches from suspension clamp.
C—Timing wave, 25 cycles per second.

rigid eccentric weight is reported[14] to give satisfactory suppression of aeolian vibration. However, on long spans of a.c.s.r. at high mechanical tension, the simple torsional damper did not give the desired degree of suppression. A modification of this damper, employing a resilient joint at the centre of gravity

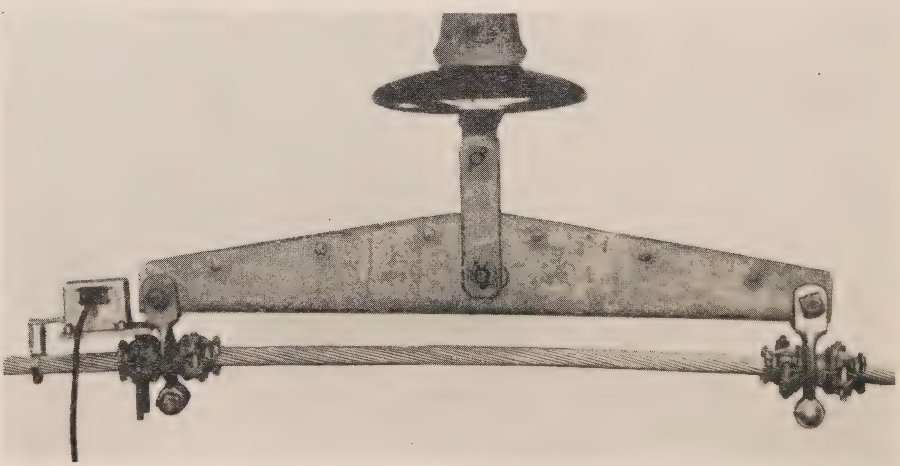


Fig. 11—Whiffletree suspension clamp on 477,000 cir. mil a.c.s.r. with deflection recorder mounted on ring-type suspension clamp.

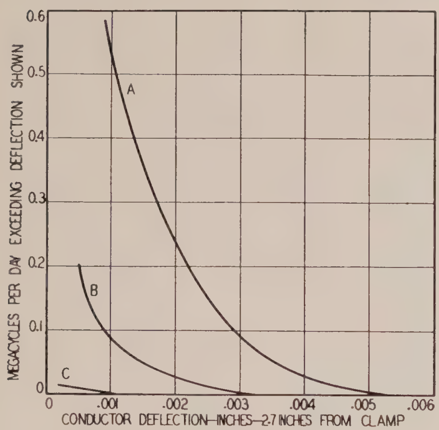


Fig. 12—Comparison of single and double suspension clamp on 477,000 cir. mil a.c.s.r. Hawk in 650-foot spans at 3600 pounds tension.

A — Single ring-type suspension clamp.

B—Two ring-type suspension clamps on 30-inch whiffletree.

C—Single clamp on span equipped with dampers.

of the weight, permitted more effective and economical design, and showed the following advantages in operation:

1. The resilient connection between the weight and conductor lessened the possibility of stress concentration in the conductor at the point of attachment.

2. Use of a material with suitable damping characteristics such as rubber or Neoprene in the resilient joint, increased the effectiveness of the damper.

3. By properly proportioning the damper weight, moment of inertia, arm length and resilience of the joint, effective suppression of aeolian vibration could be obtained over the entire range of frequencies encountered on any particular conductor.

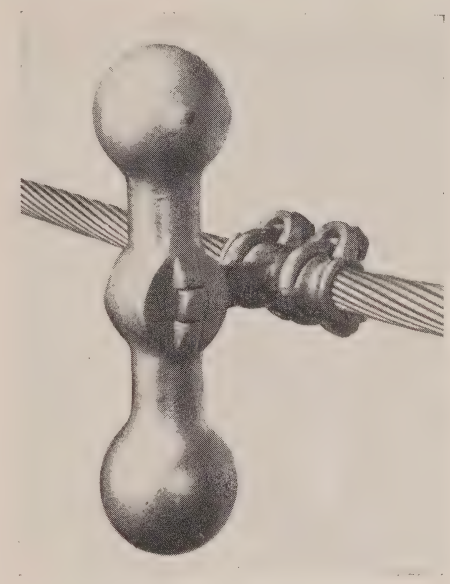


Fig. 13—Torsional damper for 795,000 cir. mil a.c.s.r.

The determination of optimum values for these factors was guided by mathematical analysis[15] but in all cases, designs arrived at by theoretical considerations were checked for performance on wind-excited spans. Fig. 13 shows a design of torsional damper found effective on 1150-ft. spans of 795,000 cir. mils a.c.s.r. "Drake" at 5500 pounds tension using two dampers per span, one mounted 6 feet from each suspension clamp.

Comparison of Dampers and Reinforcing Devices

Devices designed to suppress the amplitude of vibration throughout the span to a value which will not produce fatigue failures in the conductor, are properly called "dampers" and in this investigation two forms were tested, the

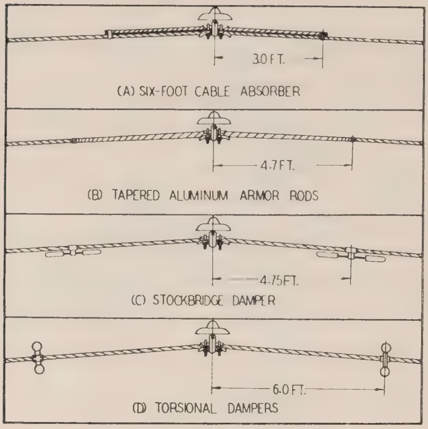


Fig. 14—Vibration control devices for 795,000 cir. mil a.c.s.r. in 1150-foot spans at 5500 pounds tension.

A—Six-foot cable absorber.

B—Tapered aluminum armor rods.

C—Stockbridge dampers, two per span.

D—Torsional dampers, two per span.

well-known Stockbridge damper, and a newly-developed Torsional damper.

Devices which act primarily as reinforcements effect only a small reduction in vibration amplitude throughout the span, but by stiffening the conductor in the region where failures usually occur, seek to prevent stress concentration. Of this type, two devices were tested: the well-known tapered aluminum armour rods which form a spiral wrapping around the conductor, and a cable absorber consisting of a six-foot length of the power conductor, carried above the main conductor in a double-barreled clamp, its ends fastened to the main conductor with light aluminum clamps.

A comparison of these four devices, installed as shown in Fig. 14, was made on spans representing a proposed 220 kv. line. The essential information for comparing their effectiveness is plotted in Fig. 15 but examination of the oscillographic records discloses other differences in operation. Spans equipped with reinforcing devices vibrate throughout the same range of frequencies as the undamped span, whereas dampers suppress all but the lowest frequencies. The Stockbridge damped span permitted vibrations at frequencies up to 3 cycles per second and deflections of 0.003 inch, of which a typical record is shown in Fig. 5. On the Torsional damped span, no deflections exceeding 0.001 inch were recorded, and no single frequency could be identified to indicate resonant vibration.

The possibility of extending the effective frequency range of torsional dampers still lower, to suppress galloping of conductors has been considered. Present conceptions of a damper to be effective at 0.5 cycles per second appear unreasonably large for general use.

Estimate Safe Deflection

For any conductor, under normal tension and supported in a specified clamp, there is some value of alternating deflection which the conductor will withstand indefinitely without fatigue failure. One method of determining this value would be to vibrate specimens of the cable at normal tension and at various deflections until a strand failure occurs. By plotting a curve of deflection on number of cycles to failure, the deflection which the cable can withstand indefinitely may be determined. This procedure, especially for large aluminum conductors which vibrate normally at low frequencies,

and which may require up to 500 million cycles to produce failure, is not considered justifiable until further investigation has determined the effects of such variables as corrosion, infrequent overstresses such as those produced by galloping conductors, surface defects or abrasions. These uncertainties must now be allowed for by an arbitrary safety factor.

The fatigue characteristics of an aluminum strand subjected to bending stress reversals, but without tension load, may be determined readily on a high speed fatigue test machine such as the Haigh-Robertson.[5] As shown in Fig. 16, the stress-life relation is such that if a stress which causes failure in one million cycles be reduced by 50 per cent, infinite life can be expected. Similarly, a stress reduction of 30 per cent will increase a ten million cycle life to infinity.

Little information is available concerning the fatigue characteristics of aluminum under the combined stresses of tension and reversed bending. It has been shown[16] that for steel, the superposition of tension on reversed bending stresses reduces the allowable stress range, but that the shape of the S-N curve is not greatly altered. Assuming that a similar relation exists for aluminum, it should be possible, for a single endurance test on a stranded conductor at a measured deflection, to estimate the safe deflection below which fatigue failures would not occur. For example, an endurance test was carried out on a 477,000 circular mil a.c.s.r. at 3,600 pounds tension, set up to approximate the field test conditions of Curves A or B, Fig. 8. The cable was vibrated

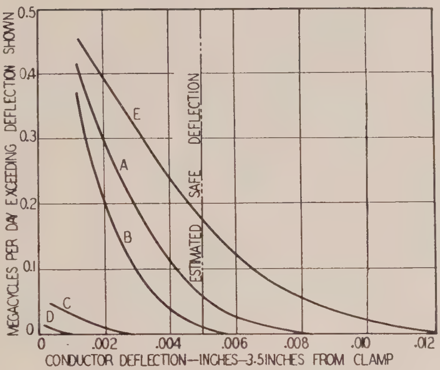


Fig. 15

A—Six-foot cable absorber.

B—Tapered aluminum armor rods.

C—Stockbridge dampers, two per span.

D—Torsional dampers, two per span.

E—Undamped span.

to produce a deflection of 0.006 inches at a distance 2.7 inches from the clamp, and the first strand failure occurred at 26 million cycles. From Fig. 16, it appears that a stress reduction of 20 per cent would have prolonged conductor life to infinity. Referring again to Fig. 8, the estimated safe deflection for the conditions of Curves A and B would be $0.006 \times 0.80 = 0.0048$ inch.

A third method, which was used in estimating the safe deflection shown in Fig. 14 is based upon operating experience with the actual conductor. Several hundred miles of 795,000 circular mil a.c.s.r. equipped with cable absorbers as shown in Fig. 14 have been in operation for 10 years. Periodic inspections have shown no fatigue failures at suspension clamps. Curve A of Fig. 15 shows that this construction has withstood deflections exceeding 0.006 inch totalling 0.030 megacycles

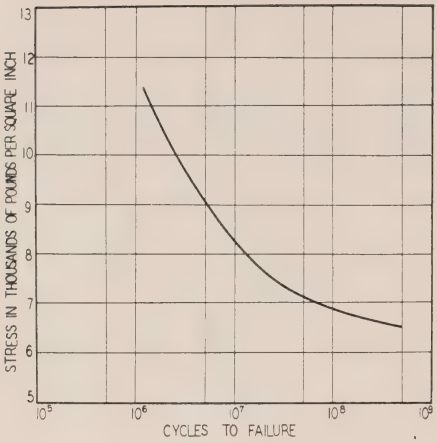


Fig. 16—Fatigue curve for 0.1059 inch diameter aluminum wire as determined with Haigh-Robertson machine.

per day, or about 100 million cycles in the 10-year period. Fig. 16 shows that a stress reduction of 15 per cent would increase conductor life from 100 million cycles to infinity, hence the estimated safe deflection is $0.006 \times 0.85 = 0.0051$ inch.

Conclusions

1. Vibration of large diameter conductors used in modern a.c.s.r. long span construction without protective devices, may be expected to produce fatigue failure of single strands in a few months to a few years, depending upon such factors as span length, tension, conductor diameter and wind conditions.

2. Reduction of both span length and tension by fifty per cent provides less reduction in vibration stresses than is accomplished by the application of suitable dampers.

3. A special stranding "loose core" a.c.s.r. effectively suppresses vibration in the upper range of frequencies. The over-all suppression is, however, much less effective than that provided by dampers on a.c.s.r. of standard stranding.

4. Reinforcing devices such as armour rods, are much less effective than dampers in reducing vibration stresses on large a.c.s.r. conductors. The advantage of reinforcing devices in protecting conductors from flashover burns may be offset by wear or strand breakage under improperly installed or loosened clamps due to vibration.

5. Available dampers reduce conductor deflections well below the limit indicated as safe both by operating experience and by fatigue tests on conductors. The factor of safety thus provided is considered adequate to cover all uncertainties in field observations or in estimating fatigue limits for the conductors.

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Georgian Bay Municipal Electric Association

THE annual meeting of the Georgian Bay Municipal Electric Association was held on Tuesday, August 26th, on board the C.P.R., S.S. Kewatin sailing out of Port McNicoll and cruising on the waters of Georgian Bay. A meeting of the Executive of the Association was held in Penetanguishene at 10 a.m. on the morning of the same day. The cruise started at 2 p.m. and continued until 8.30 p.m. standard time. The meeting was sponsored by the city of Owen Sound, and in the absence of the mayor and chairman of the Public Utilities Commission who were unable to attend, the delegates were welcomed by J. R. McLinden, the manager of the Public Utilities Commission.

At 1 p.m. an executive meeting of the O.M.E.A. was held on board the boat. Vice-presidents W. R. Strike of Bowmanville, District No. 1, A. Menary of Grand Valley, District No. 2, K. A. Christie, K.C. of Toronto, District No. 4, P. R. Lock of St. Thomas, District No. 7, and Garnet Edwards of Windsor, District No. 8, as well as the secretary-treasurer, Miss K. Ciceri of Guelph, and the president, Dr. W. J. Chapman of St. Catharines, attended this meeting and also attended the meeting of the Georgian Bay Electrical Association, which was held in the dancing salon of the Kewatin with President A. Menary of Grand Valley in the chair.

The main topic of discussion centered on the recent unemployment insurance regulations of the federal government as affecting local public utilities' and Hydro commissions' employees. A. J. B. Gray of the Provincial Department of Municipal Affairs was on board the boat, and at the request of the delegates, addressed the meeting on the application of the Federal Act and explained the efforts that were being made to clarify the situation with respect to the employees of municipal bodies. The matter of licensing electricians and journeymen doing wiring work in the various municipalities, was also thoroughly discussed with the object of protecting the public against unsatisfactory workmanship and enabling wiring work to be performed by competent workmen. No definite conclusion for taking immediate action was reached, although considerable progress was made towards bringing this matter to an early settlement.

R. T. Jeffery, Chief Municipal En-

gineer of The Hydro-Electrical Power Commission of Ontario, addressed the meeting on matters pertaining directly to the Georgian Bay system. He explained that due to the frequency changing equipment at Chats Falls and Hanover, practically all of the power facilities of Southern Ontario were being pooled for the benefits of the three major Hydro systems in that area; viz., Niagara system, Eastern Ontario system and the Georgian Bay system. Mr. Jeffery also reviewed the financial setup of the Georgian Bay system, explaining the advantage of the stabilization of rates reserve. He touched on the generating plant capacity of the eleven hydro-electric plants and the two frequency changing stations comprising the system's source of supply, and pointed out the benefits derived from the Niagara connection. Due to low flow water conditions during the present summer season, the Hanover frequency changing sets were being operated at maximum output and were supplying over 1/3 of the peak capacity and over 15 per cent of the energy of the entire Georgian Bay system requirements. Mr. Jeffery pointed out that the combined capacity of all of the Georgian Bay system's hydro-electric plants plus the Hanover frequency changing sets, was 49,050 horsepower, and that the system peak load during the month of July of this year had reached 49,897 horsepower, all of which indicated the need of the Big Eddy development now under construction on the Musquash river with an installed capacity of 10,000 horsepower. He stated that every effort had been made to place this development in operation by September 1st of this year, but on account of priority requirements of material required for munition purposes and war effort, the Commission had been unable to carry out this programme, and therefore the plant could not be placed in operation until about November of this year.

Dr. Chapman, the President of the O.M.E.A., also addressed the meeting, and stressed the advantages of co-operative effort and the relationship of the various local sections to the parent O.M.E.A. body.

The matter of the date and meeting place of the next meeting of the Association was left to the decision of the Executive, and various delegates stressed the advantage of holding future meetings on board the S.S. Kewatin as evidenced by the success of the last two annual meetings. The attendance at this meeting was given out as 387 adults and 67 children, a total of 454, with the returns from the sale of tickets resulting in a profit for the Association of between \$80.00 and \$90.00. The entire meeting was pronounced as highly satisfactory and successful both from the standpoint of profit and pleasure to all of the participants.

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Transmission of Electricity at Higher Voltages in Canada—Historical and Trends

By A. E. Davison, Transmission Engineer, Electrical Engineering Department, H.E.P.C. of Ontario

LONG distance transmission has played an important part in the development of this country, since in a large part of Canada coal, either to be transported to point of use or burned at mine mouth, is quite limited. The result is that practically all generation is hydraulic. This power must be transmitted from remote points to manufacturing and consumer centres.

Early Problems

Just prior to 1900 there was a now famous controversy in which Lord Kelvin took part, regarding the difficulties of transmitting power at the now lower voltages of the order of 11,000 volts from DeCew Falls (south of St. Catharines) to Hamilton. Very shortly after that, transmission was undertaken at 66,000 volts in such areas as the Niagara Peninsula, Montreal district, and Manitoba. The transmission problem was becoming acute because of the amounts of power to be delivered and because of the distances to be reached. One of the earlier steps was to change the then highest voltage for pin type insulators to 88,000 volts between Niagara Falls and Toronto, thereby creating practically a peak voltage for pin type insulators. This voltage was not satisfactory for the demands of the Montreal district or to serve London or Windsor from Niagara Falls, with the result that about 1910 a major step was taken in the insulation of electrical conductors and in the development of still higher voltages. Suspension insulators were introduced first for and by the Hydro-Electric Power Commission between Niagara Falls and Kitchener, and at about the same time to serve, among other areas, the Montreal and Winnipeg districts.

CONTENTS

Vol. XXVIII No. 9

SEPTEMBER, 1941

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

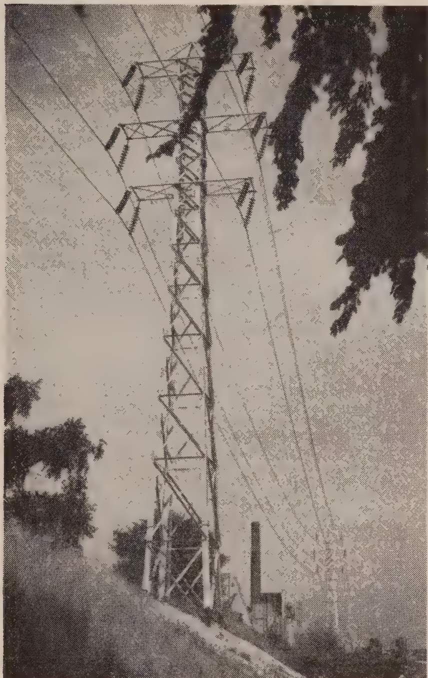
These new suspension-equipped power services were well established during the period of the Great War and Canada experienced during that period a major industrial development. This type of insulation has now become standardized and can be used with little change for almost any higher voltage.

For more detailed records of the genesis of power transmission in Ontario, Wills Maclachlan as president of the Royal Canadian Institute has recorded many facts in the Proceedings of that institute for 1940-41. Men who superintended the earliest installations in Canada are still associated with the management of works assembled as early as 1881 to 1884.

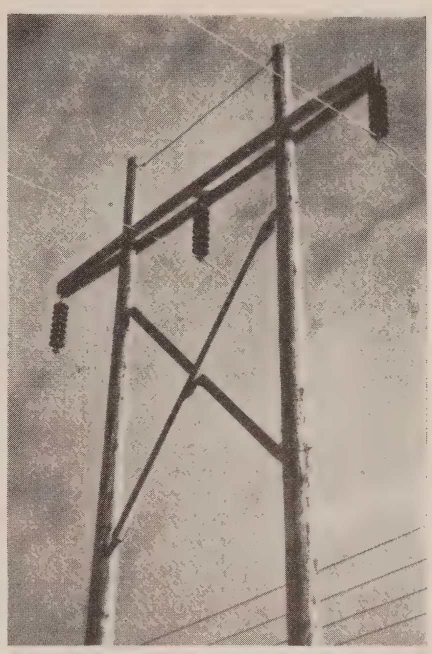
ALUMINUM CONDUCTORS STEEL REINFORCED

Up to about the time of the Great War, copper had been largely used in both distribution and transmission services, although all-aluminum conductors had been used in the Caledon district, and in 1902 eight-five miles of the latter conductor were erected between Shawinigan Falls and Montreal. About that time aluminum, with its steel reinforcements, became a com-

Four 230 kv., single circuit transmission lines on one route near Toronto; not all of one kind as the sky cables have been raised eight feet in the most recent (1940) construction at the right.



Double circuit, 110 kv. line to Toronto-Fairbank transformer station, built in 1940.



Substantial, twin pole, 110 kv. structures like this now serve important industries in many Canadian districts.

petitor, and its use, once established, became very extensive, especially at the higher voltages. Also, during the Great War steel for transmission line supports was not available, with the result that during that war wood poles were introduced for the support of higher voltage conductors. That development also has grown extensively in the meantime both in Canada and the United States. In the latter country, there has been a trend towards wood supports for higher voltage lines, largely because the electric services were being extended to less densely populated areas and to smaller prospective loads. The cheapest type of construction possible was necessary.

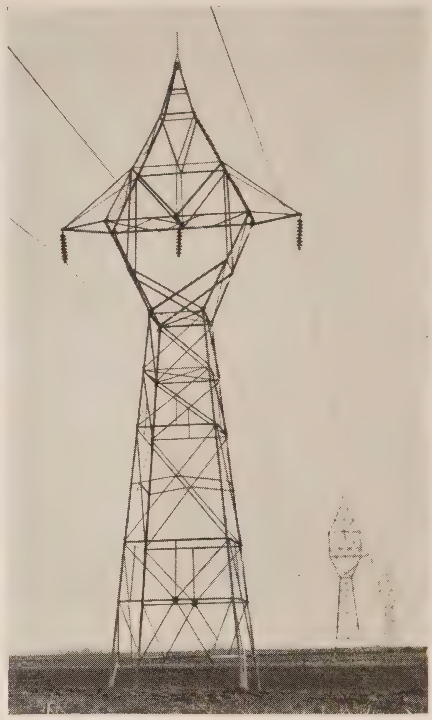
There has been of the order of the same mileage of wood and of steel supports for 110 kv. and 132 kv. lines built during the past twenty years in Canada.

About 1928, two hundred and thirty thousand volts was introduced, with the result that there are now two Canadian systems having lines built and insulated for 230-kv. During 1941, one of these systems will be operating approximately 1200 circuit-miles, the longest practical transmission distances in this system being from 330 to 350 miles.

Lightning Protection

Apart from a group of troubles, including actual mechanical overloadings which sleet or glaze create for transmission engineers, lightning is a continuing problem. Earlier lines in Can-

Wishbone construction.—110 kv., wood pole serving a mining district, angle on single pole 13 deg., guy is above conductors.



This (1939) spire-type, steel tower supports 477,000 cir. mil a.c.s.r.; the sky cable is elevated more than usually, and the cable spacings have been increased.

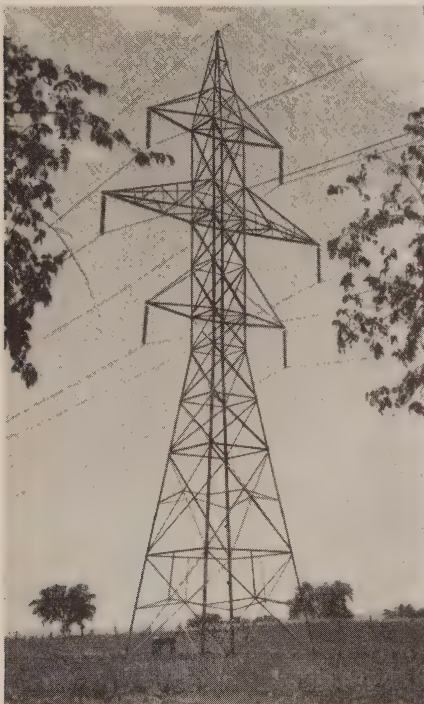
ada were not designed with lightning voltages in mind. The interruptions would be the concern of the consumer; however, it was not long until something had to be done about broken insulators and about consumer dissatisfaction. One of the earlier practices was to install an earthed wire supported by a bayonet type of pole extension above the power wires. The first of these, now abandoned on the particular line—which decision was affected by the availability of arresters at terminals—was made of barb fence wire material. Especial attention was given to the design of the barbs.

Today few lines indeed are built for voltages above 44 kv. without an earthed or sky cable, the efficiency of which depends largely upon the extent and thoroughness of the grounding.

At lower voltages the sky cable is as frequently omitted largely because of the existence on the structure, generally below the main power conductors, of a neutral wire which must be thoroughly grounded and which is associated with the lower voltage distribution circuits usually found there. Sky cables are not a guarantee against lightning, with the result that buried cables are sometimes carried from tower to tower and electrically connected to them. These, if installed and maintained two at a time, each one under the outer power wires, together with a thoroughly grounded sky cable, if it is high enough above the power cables, may be expected to provide a nearly lightning-proof line.

Contributions to Mining

During the past twenty years, one outstanding feature of Canadian transmission has been the facilitating of the



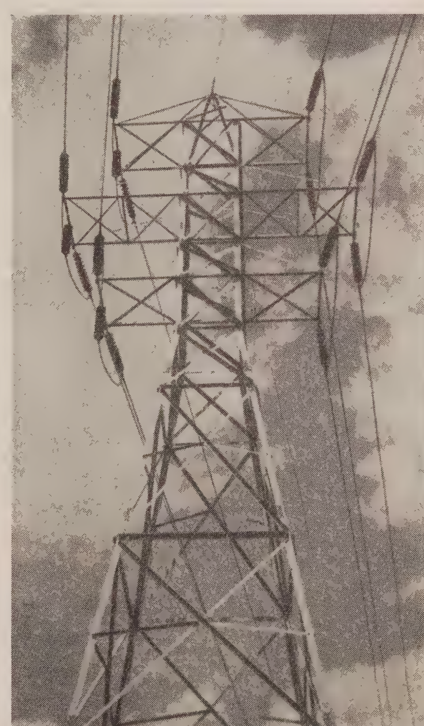
Double circuit (1940), 230 kw. lines are new to Ontario. All cable clearances are larger than heretofore. The conductor is 1.02 inch, hollow core segmented copper.

mining of precious metals. It would appear from practice that hydraulically generated power and plenty of it is fundamental to the production of gold as found in Canada.

Some of the more outstanding, if not spectacular, characteristics of lines and systems set up for the production of precious metals have to do with transport and patrol difficulties, and with comparatively new physical conditions because of the remoteness of the territory through which these lines are run.

Present Day Trends

Trends are generally toward longer transmission distances, which means higher voltages. This appears to apply to all voltage classifications from that of the 110-volt lamp and its associated wiring, where there is a tendency to step up a volt or two at a time, to the highest transmission voltages of 230, 287 and 330 kv. As voltages increase, the loads and hence the importance of the individual lines and their routes increase. Service security is sought by increasing the spacing of the already mechanically stronger conductors and by increasing the number of earthed wires above and below ground. In some areas there is a tendency toward single-circuit construction with, as soon as they can be secured, loops or duplicate service other than on the same



110 kv., double circuit, semi-anchor tower.

Queen Elizabeth Way at Stoney Creek showing tower types erected in 1906 and 1913, above auto at the left, 1924 in foreground and 1915 near far railway crossing over traffic circle. Photo courtesy the Department of Highways of Ontario.

BOX TRANSMISSION LINE — LENGTH 22 MILES

50 STANDARD SUSPENSION TOWERS, TYPE "A" - 24 ft to 59 ft HIGH
ADJACENT SPANS FROM 446 ft to 1497 ft

19 LONG SPAN SUSPENSION TOWERS, TYPE "B", 24 ft to 54 ft HIGH
ADJACENT SPANS FROM 476 ft. to 2237 ft

14 SEMI ANCHOR SUSPENSION TOWERS, TYPE "C", 24 ft to 54 ft HIGH
ADJACENT SPANS OF 476 ft to 2109 ft SET AT LINE ANGLES OF 10° to 14°

22 HEAVY ANGLE SUSPENSION TOWERS, TYPE "D", 24 ft to 64 ft HIGH
ADJACENT SPANS OF 393 ft to 2207 ft SET AT LINE ANGLES OF 4°33' to 35°38'

1 SPECIAL HEAVY ANGLE SUSPENSION TOWER, TYPE "E", 24 ft HIGH
ADJACENT SPANS OF 1504 ft and 1780 ft SET AT LINE ANGLE OF 49°

TOTAL Nº OF TOWERS 106 WITH A TOTAL WEIGHT OF 476,000 lbs.,
OR 4500 lbs PER TOWER TOWER SPACING = 4.85 SPANS PER MILE
FURNISHED BY THE CANADIAN BRIDGE COMPANY

RIGHT OF WAY CLEARED = 99 ft. WIDE LINE VOLTAGE = 66,000
TYPE K 1/0 COPPER WELD — 30% CONDUCTIVITY — 7 STRAND — 512 lbs PER 1000 ft.
OUTSIDE DIAMETER OF CABLE 0.476 inches WORKING STRESS = 7,000 lbs
DESIGN - 8 lbs of WIND and ½" of ICE at 0°F. TEMPERATURE
TEMPERATURE VARIANCE −20°F. to 120°F. NET WEIGHT = 178,000 lbs
MINIMUM GROUND CLEARANCE IS 16 FEET
COMMUNICATION BY NORTHERN ELECTRIC POWER LINE CARRIER EQUIPMENT
FOR OPERATION ON 110 VOLT SINGLE PHASE 60 CYCLES.
INSULATORS - CANADIAN PORCELAIN Nº 4700 BALL AND SOCKET TYPE UNITS
10" DIAMETER BY 5" DEEP ULTIMATE STRENGTH = 15,000 lbs.
STRAINS COMPOSED OF 7 UNITS ···· SUSPENSION OF 6 UNITS
TOTAL WEIGHT OF INSULATORS = 43,000 lbs

E. M. Stiles in the Canadian Institute of Mining and Metallurgy, August 1940, decribes in engineers language the construction in 1938 of this 22 mile, steel supported, 107 span, 60,000 volt, suspension equipped, No. 0 copper, 3300 horse power line in North-West Saskatchewan some 300 miles removed from waterways, Alberta, as follows:

"Matters not cared for in the design were the fires that ruined four reels of cable, tower parts that turned up missing, corduroy trails that sank, 'no see 'ums' that bite, men who quit—all the trimmings of a lineman's work in the bush, getting 350 tons of valuable material into its allotted place."

At Left:—

The 66 kv. insulators operating in the mountainous mining areas of British Columbia supplying power for the Pioneer and Bralorne Gold Mines, Bridge River district, are frequently subjected to conditions shown in this photograph. Deposits of snow are not infrequent but seldom cause serious trouble in the quite clear atmospheres in which they operate. Silver thaws at times load up conductors and insulators in somewhat the same way with hoar frost. These lines are owned and operated by the Bridge River Power Company, Ltd., a subsidiary of the British Columbia Power "Corporation, Ltd."

structures. There is abroad a marked tendency in service security toward building long inter-system tie lines.

Just as during the last war, certain materials used in peace time pursuits presently will not be available. Wood supports and aluminum conductors then became well established. In this war period, copper seems to be the more available.

High-speed switching is solving many of the transmission engineer's problems inasmuch as it appears possible now for commercial loads to be tripped off long enough to relieve lightning voltages and returned without any customer inconvenience.

Direct current transmission, which has certain apparent advantages, is not progressing rapidly, being generally in experimental trial in a very few locations. It awaits further development of economic satisfactory terminal equipment.

Central Canada Exhibition, Ottawa

THE Central Canada Exhibition, Ottawa, was carried on this year from August 18th to 23rd. The exhibition was not held in 1940 due to the war, but the directors decided to hold it this year having the approval of both the Dominion and Provincial Governments who were of the opinion that the fair would stimulate interest in agricultural production and also be a medium of showing the public the extent of Canada's participation in the war.

As the permanent buildings of the exhibition were housing troops or equipment of the active army, the exhibition displays were entirely under canvas which required the erection of some 132 tents. The majority of the tents were placed to the east and south of the grandstand oval and therefore did not interfere with the usual activities in front of the grandstand.

The Hydro-Electric Power Commission of Ontario and the Ottawa Hydro-Electric Commission together sponsored an educational war time exhibit. A large tent 40 ft. by 70 ft. was erected with an adequate stage at one end and a seating accommodation of 230 chairs. The program consisted of cooking demonstrations in the afternoons, and the Hydro pictures "The Bright Path" and "Keepers of the Light" were shown four times each evening.

The cooking demonstrations indicated the part that electricity can play in connection with the war effort in our homes in saving time and money. This was particularly emphasized by the use of ingredients that are plentiful in place of those of which there is a shortage. The cooking demonstrations were attended by approximately 1,800 people during the week. The films portrayed the development of the natural water-power resources of Ontario and the great expansion of the growing need for electricity in Ontario. Hydro's contribution to the production of vital war material in the electrically operated industries of the province was also graphically portrayed. Over 5,000 people viewed these pictures. S. W. Caniff, General Manager of the Ottawa Hydro-Electric Commission and his staff gave the Commission every possible co-operation and through the combined effort very satisfactory results were obtained.

Measurements of Temperature

Electrical Pyrometers

THERE are three principal methods of measuring temperature electrically. The first is based on the variation of the electrical resistance of a metal with its temperature, the second on the electromotive force set up in an electrical circuit comprising two dissimilar metals when the two junctions of those metals are at different temperatures, and the third on the fact that the intrinsic brilliancy of a luminous body depends on its temperature. Devices operating on the first principle are known as resistance thermometers and those on the second as thermo-electric or radiation pyrometers accordingly as the active junction is directly exposed to the measured temperature, or is placed at the focus of a mirror which receives radiant energy from the source of high temperature to be measured. Devices operating on the third principle are called optical pyrometers; an image of the source of high temperature is focused on the filament of an electric lamp and the temperature is measured by the current in the filament of the lamp that is required to make its brightness exactly match that of the image. Radiation and optical pyrometers have an inherent accuracy inferior to that of the more directly operating resistance and thermo-electric devices.

Resistance Thermometers

The resistance thermometer is the most versatile of electrical temperature measuring devices. The resistance of the thermometer coil is measured by comparing it with that of electrical components consisting of alloys having resistances that are unaffected by temperature change. The electrical power for operating the indicating instrument depends not only on the change of resistance of the thermometer coil but also on the electrical power put into the whole circuit, and by increasing this power input the instrument power can be made ample for indicating small temperature changes of the thermometer coil without sacrifice of robustness of construction. The resistance thermometer suffers from the drawback that an external source of power is necessary, and its accuracy depends on the constancy of the current drawn from this source; the equipment must therefore include some device either for compensating for changes of the input current or for maintaining this current at a constant value.

The thermo-electric thermometer or pyrometer is the simplest of all devices for the electrical measurement of temperature because it produces the electrical power required for operating the indicator. As the indicator is responsive to a temperature difference, either one junction of the dissimilar metals of the circuit must be maintained at a constant datum temperature or the mechanical zero of the indicator must be maintained by hand or automatic adjustment at a value corresponding to this inactive junction temperature. The power available for measuring temperatures under 500 deg. fahr. is so small that specially delicate construction of the indicator is re-

quired. Although the resistance thermometer is generally more convenient for measuring moderate temperatures, the thermo-electric method is usefully applied for measuring the internal temperature of large electrical machines, because the junctions are so compact that they can be built into windings.

Base-Metal Couples

The highest accuracy and the greatest range of temperature measurement by the thermo-electric method are given by the use of junctions or couples composed of rare metals such as platinum and rhodium. For temperatures up to 1,200 deg. fahr. base-metal couples are used, not only because they are cheaper but also because they give more power for instrument operation than do rare-metal couples. The life of a base-metal couple exposed to a temperature of about 1,200 deg. is necessarily limited, and towards the end of the life of a couple its accuracy is likely to fall off seriously.

As inaccuracy in a thermo-electric pyrometer is difficult to detect, special interest attaches to the results of an investigation recently carried out by the United States National Bureau of Standards on the useful life of base-metal couples of three types under various temperature conditions. Iron-Constantan couples maintain good accuracy with 1,000 hours' exposure to temperatures up to 1,200 deg. fahr. With higher temperatures the electrical indication tends to be low and the life to become less, failure taking place after 12 hours' exposure to 2,000 deg. and after 300 hours' exposure to 1,600 deg. Similar but somewhat better results were obtained with Chromelo-Constantan couples. Couples of Chromel-Alumel gave a useful life of 100 hours up to 2,000 deg. fahr., with a tendency for the electrical indication to be high with temperatures above 1,200 deg.

The results of this investigation show that the conditions in which a base-metal couple are used should not be changed if the highest accuracy is required. A couple that will give accurate results for temperatures below 1,000 deg. should not be exposed to any higher temperature, else the accuracy at moderate temperatures around 500 deg. may suffer. The position of a couple in a furnace should never be altered after it has been installed. It is even inadvisable to remove a couple for calibration in a laboratory furnace.

The accuracy of the indication of a thermo-electric pyrometer depends jointly on the accuracies of the couple and of the indicating instrument, and freedom from error cannot be inferred from good condition of the instrument. The Bureau of Standards investigation shows that users of couples for temperatures above 1,000 deg. should realize that the useful life is terminated not by actual failure but by falling-off of accuracy.—*Trade and Engineering.*

The Functions of a Local Commission

By J. Albert Smith, M.L.A., Commissioner, The Hydro-Electric Power Commission of Ontario

THE Ontario electrical enterprise which we know as "The Hydro" is unique in its organization and functions. It differs from other electrical supply organizations throughout the world in its origin, aims, political relations and control. The control of this great complex organization is vested in The Hydro-Electric Power Commission of Ontario, appointed by the Provincial Government. Each municipality, however, has its own commission to manage the operations of its local Hydro system, and it is in regard to the functions of these municipal commissions that I have been requested to address you today.

To convey an understanding of the duties and functions of the local Hydro commissions, it is essential first to outline briefly the functions of The Hydro-Electric Power Commission as these functions are closely interrelated to the functions of the local commissions.

The original legislation, the Act of 1906, as amplified and extended by "The Power Commission Act" of 1907 provided for the appointment of a commission named "The Hydro-Electric Power Commission of Ontario". In this Commission was vested supervisory powers and authority to act for the co-operating municipalities, and also for the Provincial Government, which loaned the funds necessary to construct power plants, transformer stations and transmission lines to supply the power required under this scheme.

An address to the Eastern Ontario Municipal Electrical Association at Oshawa, September 16th, 1941.

It is important to note that the original legislation defining the principles which were to govern this undertaking was drafted on the basis of a co-operative scheme.

The men who drafted the original Hydro legislation built on a sound foundation, because in spite of many changes made in the Act throughout the years there has been no material change made in the original co-operative principle.

The Act provides that each co-operating municipality shall sign a contract with the Commission for a supply of power, and gives the Commission authority to make such arrangements and expenditures as it considers necessary from time to time to produce, procure and supply the power requirements under these contracts. This Act also defines the basis on which the charges for power supplied shall be allocated and billed to each of the co-operating municipalities.

Amendments to this Act have, of course, been made from time to time to provide for the added responsibilities of the Commission resulting from the rapid growth of the undertaking, and also to provide for special additional duties to be performed by the Commission. However, the principle of power at cost, as established in the original Hydro legislation and the original power agreements, is still followed without important deviation.

The growth in the operations of Ontario's electrical enterprise have been truly amazing. It is true that a very rapid growth in the use of electricity has taken place in all modern states. But the primary cause of the great success of Hydro in Ontario was that electrical service was supplied under a system of co-operative enterprise that made it available to the greatest number at the lowest cost.

Today the Commission's work may be said to relate to three principal fields—the co-operative municipal field, the field of rural supply, and the Northern Ontario field. The first two cover the Commissions' activities on behalf of the co-operative systems, or groups of municipalities, and the last relates to its trusteeship of the Northern Ontario Properties on behalf of the Province. The Commission's operations on behalf of the co-operative systems also includes the sale of power to large industrial companies.

It should be noted that under their contracts the co-operating municipalities pay their share of the cost of power incurred by the central commission on their behalf. For convenience, an estimated interim rate per horsepower is used in monthly billing, but the real cost is determined at the end of the year, when a credit or debit adjustment is made. These adjustments are commonly referred to as the thirteenth bill, which usually takes the form of a credit note.

The Power Commission Act also provides that the Commission may prepare plans, specifications, and estimates, construct plants, purchase supplies and render engineering or other services for the supply and distribution of power in the co-operating municipalities.

Wide Supervisory Powers

The founders of the Hydro scheme realized that if it were to succeed there must be uniform purpose and action by all those interested. This could only be obtained by having a central supervisory body in control. The Act therefore gives the Commission wide supervisory powers, and in particular, control over the rates charged by the local authority to consumers.

The Hydro-Electric Power Commission of Ontario, as the central governing body, must in equity deal similarly with all local commissions and maintain uniformity in treatment to attain the co-operative spirit required. This is commonly understood to be attained, as all municipalities are required to enter into similar contracts agreeing to pay for all power on a cost basis to be determined as provided in The Power Commission Act. All municipalities thus obtain their power supply under similar conditions, and in turn each is required to deliver service to its customers with rates of the same structure and classification of customers. Like methods of accounting and bookkeeping of the various local commissions are imperative under such a co-operative undertaking. Supervision by The Hydro-Electric Power Commission of the rates, and the classification and treatment of customers by local commissions is therefore essential to ensure a uniformity of action.

The local interests of the individual co-operating municipalities are administered by local Hydro or Utility Commissions, which are established and operate under The Public Utilities Act. Under the Hydro scheme this Act applies with only sufficient alteration

to make it imperative that a local Hydro utility cannot be administered otherwise than as part of the general Hydro scheme. Each municipal commission manages its own local affairs, and has its own problems to solve, but the decisions of each commission dealing with its own affairs and problems must be made in the light of co-operation with the other partner municipalities, so that its decisions and actions may not be detrimental but always contribute to the success of the larger enterprise.

In The Power Commission Act are defined regulations governing the functions of local commissions and also providing penalties which may be imposed in cases of refusal to obey the instructions of the supervisory commission.

It cannot too strongly be emphasized that the co-operation of each municipality with all of the other municipalities of the system of which it forms a part, and also the co-operation of all the municipalities with the trustee or supervisory commission, that is The Hydro-Electric Power Commission of Ontario, is absolutely essential for the successful operation of a large complex undertaking of this kind.

Local Hydro Utilities

Now let us consider the organization and functions of the local Hydro utilities. In doing this it will be convenient to consider those aspects of the utilities which are inherent in its organization as laid down by law, and those other aspects which may be said to be its duties and privileges as an organization elected by the citizens of the community in which it functions.

Every local commission is a corporate body constituted under the statutes of Ontario, and endowed with definite powers to enable it to function efficiently as a business undertaking. Under The Public Utilities Act a municipal corporation may entrust the control and management of a public utility and the construction of the necessary works to a local commission. This Act also provides the means for establishing such a commission. In the case of a Hydro utility supplied with power by contract between the corporation and The Hydro-Electric Power Commission of Ontario, it is better to have a local commission in control of the local electric system. In many instances other utilities than the electric utility are placed under the control of one local commission, in which case the commission is called a "Public Utilities Commission". This arrangement in smaller municipalities gives an economical and efficient management for each service.

A Trustee for the Consumers

Where a local Hydro or public utility commission has been established to control and manage a Hydro utility, it has, by law, the right to exercise all the powers, rights, authorities and privileges conferred by The Public Utilities Act on a municipal corporation so long as the by-law for establishing the local commission remains in force. It must, therefore, conduct the business of the utility in a businesslike manner. It should engage a staff of properly qualified persons to handle the technical and business problems and should give to this staff proper direction, rules and power to act, so that the utility may be properly and efficiently handled. The local commission has often been compared in its functions to that of a board of directors of a business corporation. While this is a manner of describing its position, it is not com-

plete. Since the property over which it has control is a public property, the local commission is entrusted with it and the local commission must be concerned with the relation of the utility to public welfare. More specifically its duty is to guide the conduct of the utility business so as to give maximum service and benefit to the users and oppose any action which might be contemplated as detrimental to the utility's interests. To this end the local commission is responsible to its customers and no other municipal body has a right to interfere or counter its decisions and actions. It has been lawfully entrusted with the control and management of the utility, and is therefore in effect *a trustee for the consumers.*

Must Work in Co-operation with Council

While a local commission has been given these duties by statute, the fact must not be overlooked that certain clauses in The Public Utilities Act require it to perform certain functions which involve the municipal council and require it to work in co-operation with the council. When capital funds required for plant extensions or improvements have to be raised by public borrowing, these are to be obtained by issuing debentures in the manner provided by The Municipal Act. This requires formal procedure to be taken by the council, and co-operation between the two public bodies is essential to attain this. Other functions of a local commission exist where co-operation with the municipal council is necessary.

Must Follow Standard Accounting Practice

Every local commission by law is required to furnish a business report to the council annually, giving an operating statement of assets and liabilities, revenue and expenditure, number of customers, improvements, extensions, and provision for debenture payments. The council may also require such information from time to time. Also, the record of the local commission's proceedings shall be kept available for the inspection of any person appointed by the council. The accounts of the local commission shall be audited by the auditors of the corporation, and the local commission shall furnish such information to these auditors to assist them. An audit by the corporation's auditor is required, but the local commission may engage its own auditor if it so desires and bear such expense. Separate books and accounts must of course be kept for each public utility. These are all statutory requirements of a local commission.

A section of The Power Commission Act provides that a system of bookkeeping and accounting must be installed as prescribed by The Hydro-Electric Power Commission. This ensures uniformity among the co-operating utilities in the large Hydro scheme. Its importance cannot be overrated for determining the fair adjustment of cost of power to the utility and for maintaining equitable rates to consumers. The Commission's accountants make frequent visits to all municipalities and make a thorough check of all revenues and disbursements of the local utility. It is not difficult for the accountants of the local commission to follow the accounting regulations as prescribed by the Commission, and the books of all public utilities should be kept up-to-date, so that they may be checked at any time.

Salaries and Meetings

The local commissioners may be paid a salary fixed by the council from time to time, and there are many places where no salaries are paid. As far as the electric utility is involved, such salaries or part chargeable thereto shall be subject to the approval of The Hydro-Electric Power Commission and cannot be changed by council without its consent. When the local commission is entrusted with one or more other public utilities than the electric utility, the consent of The Hydro-Electric Power Commission is required if more than a pro rata share of any cost incurred for any joint use is charged to the electric utility. Local commissions do well to recognize these obligations.

Meetings of local commissions should be held regularly and proper records of such meetings kept by a duly appointed secretary. Regulations in regard to the manner of conducting the business, and proper control and management of the utility, should be provided by resolutions available in these records for the guidance of the staff. They should then be required to enforce these regulations without interference from individuals, including commissioners or municipal officials, so that impartial treatment to all may be attained. So long as the employees enforce the regulations adopted, they should receive the support and protection of the local commission against criticism. The local commission *must assume the responsibility* for control and management with which it has been entrusted. Its employees follow out the adopted regulations.

Rates to Consumers

Rates for electric power and energy are subject to the approval and control of The Hydro-Electric Power Commission. Under these regulations the Commission sets out a form of rate structure, which it insists that all municipalities follow; otherwise one municipality may operate to the disadvantage or detriment of the other municipalities served from that system.

Probably no procedure in the set-up of the Hydro organization has contributed more to its success than the application of scientific rate schedules adopted by the Commission to reflect the policy of service at cost. The Power Commission Act provides a rigid safeguard against discrimination in supplying electric power or energy to consumers. The Hydro-Electric Power Commission has prescribed a set of regulations called the "Standard Interpretations of Rates", which set out in detail how the various rates must be applied. These Interpretations of Rates are discussed at meetings at which committees composed of your managers are present. They are changed from time to time to meet changing conditions of the supply and use of power.

Disposal of Surplus Funds

The operations of your Hydro utilities have in all cases been financially successful. Notwithstanding repeated rate reductions the local commissions have been able in most cases to meet the cost of additional plant extensions out of surplus funds. In certain cases where rapid growth in population has taken place, the provision of additional distribution facilities has involved the use of new capital. Most local commissions have from year to year surplus moneys which must either be invested in bonds and held as security against

possible future losses, or returned to the consumers as a rebate in their power billings.

The Power Commission Act very definitely prescribes that these surpluses can only be dealt with in the manner and for the specific purposes set out in the Act and then only after obtaining the approval of The Hydro-Electric Power Commission. In spite of these statutory regulations, however, we find cases in which local commissions have violated their trust by attempting to make donations to charitable institutions in their municipality from the trust funds of their Hydro utility. Neither The Hydro-Electric Power Commission nor the local commission has any authority to use these trust funds in making donations to charitable institutions. The Power Commission Act definitely prevents it. In all cases where such donations have been made the Commission has insisted upon the return of the money.

With the approval of The Hydro-Electric Power Commission, surplus funds of a Hydro utility may be applied to the purchase of a site and the erection of buildings for the occupation and use of the municipal commission. Subject to the approval of the Commission any such office building may be larger than is required for the immediate use of the municipal commission, and any part of such building not immediately required may be leased to the corporation or to any other municipal commission for the purposes of any public utility in the municipality. In many cases very fine public utility buildings have been financed in this manner and form a municipal asset in which the citizens take a legitimate pride.

Accounts in Arrears

One of the most frequent violations by local commissions of the Commission's regulations occurs with regard to the collection of accounts in arrears. This is one of the most serious problems with which our engineers and accountants have to deal.

Some members of local commissions hesitate to discontinue service to a customer when his account is in arrears, especially when this customer may be a neighbour or friend of the commissioner. Almost every week letters are forwarded to municipalities giving a list of outstanding accounts, some of them many months in arrears, and calling attention to the regulations of The Power Commission Act and insisting that these accounts must be collected or the service discontinued.

In spite of these repeated instructions, some commissions refuse to obey the Commission's instructions and allow many accounts to run further and further into arrears until it becomes necessary to write off many of these accounts as bad debts.

In some cases these conditions have become so bad that the Commission has had to instruct the members of its staff to take charge of the entire billing of certain local commissions for a time and send out accounts covering outstanding arrears, and either discontinue the service to these customers or make arrangements for the payment of the account. I find this to be one of the most serious problems in connection with the operation of local Hydro commissions. Some local commissioners *seem to forget that they are handling trust funds and also forget that accounts, which are not paid by the con-*

sumers owing them, must be paid indirectly by other consumers.

I am suggesting that all local commissioners on this system and other systems, where unpaid accounts have been outstanding for many months, consider their obligations as commissioners and at once commence to fulfil the obligations they assumed when they were elected to act as Hydro commissioners.

Duties and Privileges

Apart from the functions exercised by the local commission in accordance with the governing acts, there are certain duties and privileges which devolve upon it as an elected body functioning upon behalf of the citizens generally.

It must give careful administration —making sure that its every act is in accordance with the governing acts and the regulations of The Hydro-Electric Power Commission of Ontario.

It must give economical management. The Hydro interpretation of service at cost has always been the best service at as low a cost as is consistent with long term economical planning. Widespread distribution has always characterized Hydro service. So far as wholesale service is concerned, the policy and practice is to extend service to every community that can economically be reached by Hydro transmission lines. Similarly, local utilities should strive to give the best possible service to every citizen of their community.

Safe operation is important. It implies the best in equipment and insistence upon the safety-first programmes urged by The Hydro-Electric Power Commission.

Equitable and courteous treatment of all customers in all classes of service is of paramount importance. Hydro officials should at all times remember that they are the servants of the citizens, and goodwill each to the other should characterize the relationship between the utility commission as represented by its employees, and those it serves.

Above all, the local commission should so govern its actions that the utmost co-operation is maintained between the several municipalities of the group or system to which it belongs, and between them and The Hydro-Electric Power Commission of Ontario.

Co-operation Essential

In the operation of a public utility many problems arise from time to time with which the local commission must deal. These may be problems involving policy, finance, operation, engineering, accounting or administration.

The local Hydro commissions are well safeguarded and protected from making faulty decisions on important matters by having definite regulations to follow as laid down by The Hydro-Electric Power Commission. Engineers and other officials of the Commission's staff are at all times available to give assistance and advice to local commissions. The managers of all Hydro utilities should, therefore, keep in close touch with the Commission's municipal engineers and consult these men freely when any doubt arises with regard to the administration of the local system, problems of rate applications, accounting difficulties, distribution or other problems. Matters of policy in which any doubt occurs can always be referred to The Hydro-Electric Power Commission for its advice and instruction.

I feel that the municipalities of this Province are to be highly commended on the exceptionally fine type of citizens that have from time to time during the past thirty years been elected to the office of local Hydro commissioners. Many of these men have given years of their time and energy to the efficient administration of the various commissions throughout the Province. For these men I have the highest regard and admiration.

Historic Poetry

When Wendell Willkie went to England, President Roosevelt gave him a personal letter to Mr. Churchill in which he quoted from Longfellow's poem, "The Building of the Ship":

Sail on, thou Ship of State,
Sail on, O Union, strong and great!
Humanity with all its fears,
With all the hopes of future years,
Is hanging breathless on thy fate.
We know what Master laid thy keel,
What Workmen wrought thy ribs of steel,
Who made each mast, and sail, and rope,
What anvils rang, what hammers beat,
In what a forge and what a heat
Were shaped the anchors of thy hope!
Fear not each sudden sound and shock,
'Tis of the wave and not the rock;
'Tis but the flapping of the sail,
And not a rent made by the gale!
In spite of rock and tempest's roar,
In spite of false lights on the shore,
Sail on, nor fear to breast the sea!
Our hearts, our hopes, are all with thee,
Our hearts, our hopes, our prayers, our tears,
Our faith triumphant o'er our fears,
Are all with thee,—are all with thee!

Prime Minister Churchill, in his radio address of Sunday, April 27th, wound up by quoting the poem of Arthur Hugh Clough, "Say Not the Struggle Naught Availeth":

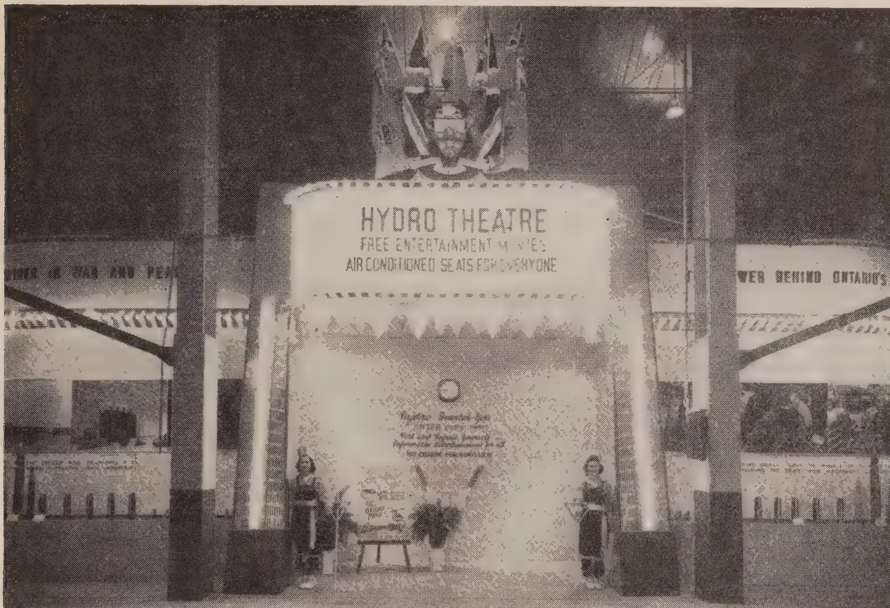
Say not the struggle naught availeth,
The labour and the wounds are vain,
The enemy faints not, nor faileth,
And as things have been, they remain.

If hopes were dupes, fears may be liars;
It may be, in yon smoke concealed,
Your comrades chase e'en now the fliers,
And, but for you, possess the field.

For while the tired waves, vainly breaking,
Seem here no painful inch to gain,
Far back through creeks and inlets making,
Comes silent, flooding in, the main.

And not by eastern windows only,
When daylight comes, comes in the light;
In front, the sun climbs slow, how slowly!
But westward, look, the land is bright!

—*The Blue Bell.*



Front View of Hydro Theatre at the Canadian National Exhibition.

The "Hydro Theatre"

A Feature Attraction at the 1941 Canadian National Exhibition

A FEATURE attraction among the interesting displays in the Electrical and Engineering Building at the 1941 Canadian National Exhibition in Toronto was the "Hydro Theatre". Located in the centre of the huge building, immediately opposite the main entrance—and flanked by the impressive war materials exhibits of the Department of Munitions and Supply and the John Inglis Company—the theatre succeeded in drawing nearly 25,000 exhibition visitors to daily showings of the Commission's talking motion pictures, "The Bright Path" and "Keepers of the Light". At the close of each performance, everyone in the audience was handed an attractive souvenir of the occasion, in the form of a colourful rotogravure magazine entitled "Power—for War and Peace."

Modernistic Design

Designed and constructed under the direction of the Sales Promotion Department, the theatre was styled in the modern, "streamline" manner. The front entrance with its flashing coloured lights, fluttering pennants, glittering chrome decorative effects and rainbow-hued pylons seemed to exert a magnetic influence on the "Ex" crowds, as most people coming in through the main entrance of the building headed directly for the brilliantly lit theatre. As a matter of fact, the flashing overhead lights and the name "Hydro Theatre" were plainly visible from the street

fronting the building. The walls of the theatre, sixteen feet in height, were gracefully curved at the corners, in keeping with the streamline design. At each end of the structure, pylons similar to those at the entrance added a decorative touch as well as the necessary structural reinforcement. Along the whole length of the front wall a line of flashing coloured lights, mounted against a background of shining chrome plate strip, gave extra life and animation to the effect. Above the lamps, in large relief lettering was given the theme of the exhibit, "Hydro—Industry's Partner in War and Peace—the Power Behind Ontario's War Industry." Similar lettering on the rear walls emphasized Hydro's assistance to agriculture and the mining industry in their war production programmes.

Impressive Photo "Gallery"

Mounted on the walls at just a little higher than eye-level were twenty-two impressive photographic enlargements, which graphically told the story of Hydro's part in the war effort from the harnessing of the waterways, through the stages of generation, transmission and distribution, to the utilization of Hydro power in industrial plants, in the mine, in the urban home and on the farm.

Beneath the pictures a special shelf was built to carry the attention-getting display of shells being made in Ontario plants, with machines operated by Hydro power, for the air force, navy and army. In the corners at the front of the theatre two Bren guns were mounted and attracted much attention.

Passing through the entrance lobby, visitors found themselves in a completely appointed theatre, with comfortable seating accommodation for 150 persons. The theatre was completely enclosed, with a roof of black cloth. The inside walls were attractively draped in deep midnight blue.

The stage was also draped, with a bank of fernery at front and two huge baskets of flowers in the corners, lit up effectively with blue lights. On both sides of the stage rooms were built, one serving as a cloakroom, the other as a dressingroom for the usherettes.

Air Conditioning

A comfort feature of the theatre much commented on by visitors was the efficient air conditioning system. Two large air conditioning units of the most modern type were installed adjoining the projection booth. With both in operation, it was possible to change the air inside the theatre every few minutes. The result, of course, was a most pleasing freshness of atmosphere at all times. Coming in from the hot and dusty grounds outside, visitors doubly enjoyed the movies thanks to the refreshing cool air provided by the equipment.

Charming Usherettes

Visitors who thronged to the theatre during the fourteen days of the exhibition were capably and courteously attended by a corps of six usherettes. There young ladies not only performed the very necessary duties of ushering the large crowds in and out, but also lent an extra "eye-appeal" to the exterior of the theatre, where they stood on duty between showings to answer the public's questions.

The very attractive costume worn by the usherettes was specially designed to resemble a Hydro lineman's outfit—right down to such details as the safety belt and pole-climbing spikes. With red blouses, they wore blue overalls, trim-

med with white. The belt and other accessories were white. Loops were sewn in the belts and in these were carried models of the regular lineman's pliers, hammer, screwdriver, etc.—made of wood for lightness.

11 SHOWINGS DAILY

"The Bright Path", which most Hydro employees have seen, was the first picture presented in the theatre programme—followed by the Commission's new, shorter talking movie, "Keepers of the Light", which tells the story of Hydro's part in Ontario's war effort. Shown together, the two pictures gave a programme running to a little over forty-five minutes.

Eleven complete showings were given every day, which meant an almost continuous performance from 10 a.m. to 10.30 p.m. when the building closed.

ATTENDANCE 1600 PER DAY

All through the period of the exhibition a careful record was kept of the daily attendance at the theatre. On certain days, attendance ran well over 2,000—while the average daily attenddance was a little over 1600 persons. When it is remembered that the theatre offered 150 seats, it can be realized that the showings were presented before near-capacity houses at all times. At some showings when seats were all taken, many people stood at the rear throughout the performance. The attendance figure of 1600 per day average was a conservative count, allowance being made for visitors who did not remain for a full showing.

A SUCCESSFUL ACTIVITY

Looking back, the Sales Promotion Department feels that the "Hydro Theatre" can be viewed as a most satisfactory activity. 22,400 people, by actual count, saw a complete performance of both pictures—with many more hundreds, if not thousands, seeing at least part of the programme. It is safe to say that through the forty-five minutes of talking movies presented, all these exhibition visitors received a far clearer and more interesting impression of just what their Hydro system is, and how it operates for their benefit, than could be put before them in any other way.

Motion pictures offer one of today's most valuable mediums of informing and educating the public. In the successful presentation of our own pictures to these many thousands of Ontario citizens, Hydro has taken a definite, forward step in the programme of inculcating a clear and intelligent appreciation of Ontario's great public utility in the minds of the general public.

Eastern Ontario Municipal Electrical Association

THE Annual Convention of the Eastern Ontario Municipal Electrical Association was held in Oshawa on September 16th and 17th with 195 delegates registered.

The president, R. W. Strike, of Bowmanville welcomed the delegates and spoke on the necessity of co-operation by every utility in the district at this time of stress of war, of the necessity of every utility joining the Municipal Hydro-Electric Pension and Insurance Scheme, on Unemployment Insurance, and on the cost of living bonuses to employees.

Reviewing the power situation in Eastern Ontario, G. F. Drewry of the Hydro Commission advised that the present war load in the district was approximately 11,000 h.p., and that the ultimate war load, together with new industries, would be approximately 36,000 h.p. He stated that the system peak would no doubt reach 180,000 h.p. by the end of the year.

J. Albert Smith, Commissioner of The Hydro-Electric Power Commission of Ontario gave an address entitled "The Duties of a Local Commission" which appears elsewhere in this issue.

At a complimentary dinner provided by the Oshawa Public Utilities Commission, the delegates and guests were welcomed by Mayor J. C. Anderson. The main speaker of the evening was Alexander Gray of Gray Forgings Company of Toronto, whose subject was "Survey of War Conditions". Other speakers were J. Albert Smith, George Garner, Commissioner, Oshawa P.U.C. and The Hon. D. G. Conant, Attorney-General of the Province of Ontario. William Boddy, Commissioner, Oshawa P.U.C. was chairman. After the dinner the assembly became the guests of R. S. McLaughlin at his beautiful Italian Gardens.

At the session on the second day M. J. McHenry of the Hydro Commission gave a short illustrated talk on the Madawaska development. Following this, R. T. Jeffery, Chief Municipal Engineer of the Ontario Hydro presented a paper on the Municipal Hydro-Electric Pension and Insurance Plan. Dr. Wm. J. Chapman of St. Catharines, President of the Ontario Municipal Electric Association, spoke briefly on the Provincial Association and congratulated the Eastern district on its splendid convention. This session was followed by a luncheon when N. J. Lake of the H.E.P.C. presented a moving picture "Keepers of the Light".

Officers elected for the year 1942 were:

President—W. R. Strike, Bowmanville.

Vice-President, Western Section—Wm. Boddy, Oshawa.

Vice-President, Eastern Section—Geo. E. Findlay, Carleton Place.

Directors—M. P. Duff, Belleville; W. B. Reynolds, Brockville and Gordon S. Matthews, Peterborough.

Secretary - Treasurer—G. E. Chase, Bowmanville.

Recommended Practice of Street Lighting

The publication of the Illuminating Engineering Society as reviewed by Geo. G. Cousins, Supervising Lighting Engineer, H.E.P.C. of Ontario

THE use of lighting to render streets and highways safe for pedestrian and vehicular traffic at night has fallen far behind the demand caused by increased use of and speed of motor vehicles. Records show that about 2/3 of the day's accidents occur during hours of darkness, when the traffic density is only about 1/4 to 1/3 of the density during daylight. This is not because the careful drivers remain in at night, nor because drivers are more careless at night. Fatigue may dull the edge of a driver's alertness, but this is a contributing cause; not the main one. The only difference of a fundamental nature between day and night is the inability of drivers to see the road and its immediate surrounding. The collision of a car with a pedestrian may be caused by a fraction of a second's delay in seeing the danger.

There are no data to substantiate a claim that law enforcement or educational campaigns have any real effect in the reduction of night accidents. On the other hand records have shown that during safety drives night accidents have increased, while day accidents have decreased. There is a large accumulation of data pointing to adequate lighting as the only means of reducing the deadly toll of night accidents.

For many years the Illuminating Engineering Society Committee on Street and Highway Lighting has applied itself to a study of this problem. "Recommended Practice of Street Lighting", its latest pronouncement represents the accumulation of a great deal of technical study, traffic surveys and analyses of traffic accidents. It furnishes a technical basis for the design of effective street lighting.

The following abstract is composed of quotations bearing on some of the more important aspects of the subject. "Recommended Practice" is a manual that merits detailed study by all those interested in this very important matter.

Underlying all other objectives, the fundamental purpose of street lighting is to produce the illumination requisite for good visibility at night, and, through good visibility, to promote safer use of streets.

Street lighting contributes effectively to the prevention of pedestrian and vehicular traffic accidents and their resulting toll of human life, personal injuries, and economic losses. This contribution is proportional to the effectiveness of the street illumination in providing visibility adequate for accurate, certain, and comfortable seeing.

In addition to its value in reducing traffic accidents and deterring crime, good street lighting encourages development of business districts, enhances property values, and makes more effective use of the large investment in street and highway construction.

Traffic safety at night has become a matter of split-second seeing.

Street lighting, generally, has not kept pace with the evolution of modern street transportation. As a result, the majority of our streets do not have lighting requisite for safety of motorists and even less so for pedestrians.

For an appreciation of the situation it is helpful to contemplate the contrast between a locomotive engineman and an automobile driver moving ahead on a dark and foggy night. Neither can see far ahead. Both must proceed partly on faith. But the engineman has the protection of a private right-of-way and block signals. The motorist lacks both. The tragic magnitude of night traffic fatalities is compelling attention to these circumstances.

Visibility is most intimately and intricately entwined in all aspects of traffic safety. The term visibility, as applied to seeing for night safety on streets, denotes the extent of possible recognition of important roadway details and objects by an observer possessing so-called normal vision.

At night a veil of darkness turns over to man the task of providing the visibility required for the safe, comfortable and convenient use of the streets. While there are some other factors, lowered visibility is a major difference in the hazards of night and day driving. The major problem in protecting street traffic at night, therefore, is the provision of lighting on streets such that motorists and pedestrians can see each other clearly and quickly, and thus avoid accidents.

Under the plentitude of light in the daytime physiological reactions are likely to be instinctive or automatic. Under conditions of street lighting at night, where the amount of light is quite limited, more of deliberate observation and judgment is involved in discernment, and reactions are likely to be less prompt and sure. It is important that those responsible for planning street lighting installations shall appreciate this distinction between day and night vision, and shall seek as close an approach to daytime visibility as it is practicable to provide through street illumination. Complacence under conditions of grossly inadequate street lighting is unjustifiable in view of the now well understood relation between safety and good street lighting.

METHODS OF DISCERNMENT

The minimum degree of seeing of direct safety value to motorist and pedestrian is the ability to recognize the presence of an object and its identifying contours. There are several methods of discernment obtainable in street lighting. Principal among these are: Silhouette, Reversed Silhouette, Surface Detail, Glint and Shadow.

Silhouette

An object is discerned by silhouette when the general level of brightness of all or a substantial part of it is lower than the brightness of its background. This method of discernment predominates in the observation of distant objects on lighted streets and highways.

Silhouette vision is of major importance in the discernment of objects in the roadway between curb lines.

When an object is seen by virtue of the variations in brightness or color over its own surface, without regard to its general contrast with its background, it is discerned by surface detail. Such brightness depends upon direct illumination, of a relatively high order, on the side toward the observer.

Pavement is largely obscured by a shifting pattern of vehicles.

All agree that lighting planned primarily for the silhouette method gives maximum protection against collision for a very moderate expenditure.

Street lighting for traffic safety is not necessarily high intensity lighting; it is light properly directed and distributed to provide the best practicable visibility at night.

With the exception of some business streets, rarely at the present time are streets lighted sufficiently to permit discernment of objects in or along streets by reason of their own brightness alone. Where traffic is more complex and seeing by silhouette is interrupted by the density of traffic, adequate lighting for seeing objects in detail should be provided.

A high ratio of night to day accident rate is evidence that the existing lighting should be improved. This is particularly true where night accidents have frequently involved pedestrians.

Because of the financial consideration involved, it is seldom practicable at one time completely to modernize the lighting system of an entire city. Rather, it is necessary to approach the improvement of street lighting by consecutive steps, selecting first the places of greatest need according to the night accident records, thus obtaining quickly and economically the greatest results in accident reduction.

Along with such selective improvement on streets now insufficiently lighted, every new street constructed should include lighting facilities sufficient for its needs in accordance with these lighting recommendations.

Experience has shown that where good visibility is provided the night accident rates are reduced one-third, one-half, or often more.

Where pedestrians are many or streets are unusually wide, the pedestrian accident problem may be particularly acute at night. This circumstance accounts for a large part of the night motor vehicle accidents and particularly of the fatalities.

Lighting Fundamentals

The installation and operation of a street lighting system should be accomplished with economy in order to secure to the public the utmost of lighting effectiveness which can be had for the expenditure involved. Expenditure, purely for aesthetic reasons, is hardly justifiable until good visibility shall have been secured.

Unlighted stretches between luminaires should, of course, be avoided. Uniformity of street surface brightness is generally desirable.

Types of luminaires and their accessory light-controlling equipment are designed to produce a given character of light distribution at a definite spacing and mounting height ratio. It is important that this ratio be respected and that the proper size lamp be used.

Since it is necessary to direct sufficient light over an entire street area to secure adequate visibility, it is particularly important that the width of the street be given due consideration in the selection of luminaires. Care must be taken when using light-controlling equipment not to direct an objectionable amount of light to the buildings across the street, particularly on narrow streets.

Mounting heights are to be determined with due consideration for lamp size, glare, extent of foliage interference, and appearance.

For identical quality of lighting with respect to average illumination, uniformity, and glare, costs of installation and of maintenance are generally re-

the eye and decreases with greater mounting heights. Increased mountings will in general give improved illumination results.

TABLE I—MINIMUM ACCEPTABLE MOUNTING HEIGHTS FOR LUMINAIRES

Lamp size in lumens	When using luminaires of max. concentration (Beam c.p. approx. 6/10 of lumen rating) See Note (b)	When using semi-concentrating luminaires (Beam c.p. equals 3/10 of lumen rating) See Note (c)	When using diffusing globes only, (Max. c.p. approx. 1/10 of lumen rating)
1000 (d)	15 feet	15 feet	15 feet
2500 (e)	18	18	18
4000	20	18	18
6000	22	18	18
10000	25	21	18
15000	28	24	18
25000	33	27	20

Note (a) Observe that the above are recommended minimum mounting heights. Higher mounting heights than these generally are preferable.

(b) For example a reflector-refractor type of luminaire providing this high degree of concentration.

(c) There are other luminaires which have been designed to give some degree of light redirection with reflecting or refracting equipment (sometimes using outer globes) which do not attain the high degree of concentration defined in Column 2. From a glare standpoint these can be mounted somewhat lower as indicated.

(d) The 1000-lumen lamps are to be used for between-intersection lighting only, on very light traffic streets and in alleys. There are no conditions of street lighting prevailing in the United States which justify the use of smaller than 1000-lumen lamps. The 2500-lumen lamp is the smallest size which may be used with good economy.

(e) On forested streets a 15-foot mounting height for 2500-lumen lamps may be permissible provided close spacing is used with post-top units.

duced by increasing mounting heights over those typical of present practice. This arises because low mounting heights are properly associated with close spacings, thus decreasing the size and increasing the number of lighting units. Also light distribution along the street will be generally improved by higher luminaire mounting heights.

The glare from street lamps increases with the candlepower directed toward

It is important not to exceed the maximum spacing-mounting height ratio for which the luminaire was designed.

In general, it is agreed that, without going to extremes of separations which leave dark areas midway between luminaires, it is better practice to use larger lamps at reasonably wide spacing and higher mountings than to use smaller lamps at more frequent intervals with

lower mounting. This is an economical procedure and is usually in the interest of good lighting results, provided the spacing-mounting height ratio does not exceed 8 to 1.

Transverse Location of Luminaires

Luminaires should be mounted out from the curb over the roadway for the most effectual utilization of the light. When mounted back of the curb line, luminaires might be spaced so as to produce the same illumination intensities as when mounted over the roadway, but the resulting pavement brightness and consequent visibility would not be so good.

The illumination values herein recommended are based on luminaires mounted over the roadway. For equivalent visibility, luminaires mounted back of the curb line must be arranged to produce much higher illumination values.

Opposite or staggered spacing should be used on streets 40 feet or more in width between curb lines, and is often preferable on narrow streets.

On traffic streets it is desirable to mount the units on the outside of curves in order to secure satisfactory pavement brightness.

Glare

The effects of glare in street lighting may be classified as follows:

(1) Reduction in ability to see
- (a) As experienced by observers under test conditions.
- (b) As experienced by users of a street.

(2) Ocular discomfort

(3) Detraction from the good appearance of a street.

A generally recognized means of minimizing the effect of glare consists in raising luminaires well above the street level in order to remove them from the visual axis. In proportion as the candlepower and brightness are high in the direction toward those using the street, it is important to take precautions to minimize glare. Reasonably high mounting is recognized as an effective means of accomplishing this purpose.

Appearance

Street lighting equipment should reflect good taste and sense of propriety. Simplicity, dignity, and grace always meet with favour as a visible expression of a civic service. Luminaire supports and equipments should blend harmoniously with the surrounding architecture. Uniformity of appearance of equipment is desirable. So far as is compatible with good visibility, the lighting equipment should be inconspicuous.

Good visibility having first been obtained, it is important to achieve the most pleasing appearance and the best practicable general effect.

Operation

Reliability of service and thorough upkeep of the entire installation is essential.

It is desirable to adopt systematic methods including:

- (a) Operation of the light sources at rated voltage or current.
- (b) Replacement of unduly depreciated lamps.
- (c) Thorough cleaning and maintenance of equipment at stated intervals dependent upon local conditions. Inadequate cleaning and maintenance schedules may result in a 50 per cent reduction in illumination.

STREET PAVEMENTS

Good *pavement brightness* is the essential requirement for *discernment by silhouette.* It is evident that the degree of brightness obtained from the light applied is dependent on the reflection characteristics of street pavements.

In proportion as the pavement is specular, it becomes important that the light from the luminaires be delivered to the pavement surface from such directions that the more or less regular reflection will be in the direction of drivers using the street and will spread a sheen of brightness over the street surface as viewed by them.

Light striking the pavement in a direction toward the observer contributes most in making the surface appear bright. The light striking the pavement in a direction away from the observer is of little value in building pavement brightness for the motorist.

In general, placement of modern luminaires out from the curb and over the driving lanes or roadways, properly spaced and mounted with regard to light distribution characteristics, can provide pavement brightness of sufficient amount and fair uniformity for safe and comfortable use of the streets at night. Under such conditions, there would be no areas of dangerously low visibility.

LIGHTING RECOMMENDATIONS

In view of the complexity of the problem and its many variables, it is evident that lighting effectiveness depends upon a comprehensive knowledge of the requirements and a skillful application of the principles of street illumination.

The average footcandle values of illumination recommended herein are considered by the Illuminating Engineering Society's Committee on Street and Highway Lighting to be the minima that should be delivered on the street to provide a reasonable degree of safety, effectiveness and convenience.

Experience has shown in many instances that illumination values higher than those given in the following table are justified by the increased safety, effectiveness and convenience afforded to those using the streets at night. There are many street lighting installations throughout the country which now exceed these values. The Illuminating Engineering Society's Committee advocates this better lighting.

CLASSIFICATION OF STREETS

To serve its purpose effectively, adequately and economically, a street lighting system should be built up from a definite plan, based on a comprehensive survey of all publicly used streets in the community.

The volume of traffic is a principal factor in determining the amount of illumination required for safety. In residential districts, illumination must be adequate for general protective and police purposes.

If it is indicated that a zone of high illumination must adjoin one of a much lower order of illumination, it is recommended that the higher be graded into the lower, beginning at the points of differing classification and continuing for a distance sufficient to permit motorists' eyes to become accommodated to the change. Ordinarily moderate changes may be disregarded.

Where a definite trend toward another classification of a street is apparent, it is in the interest of economy to anticipate this change in so far as possible.

It is recommended by the Street Lighting Committee of the Institute of Traffic Engineers that streets be classified in accordance with their traffic, as follows:

TABLE II

Classification of Traffic	Volume of Vehicular Traffic (maximum night hr. both directions)
Very light traffic	Under 150
Light traffic	150 - 500
Medium traffic	500 - 1200
Heavy traffic	1200 - 2400
Very heavy traffic	2400 - 4000
Heaviest traffic	Over 4000

Average Footcandles, Minimum For Night Traffic Safety

The average footcandle values shown in this table apply to the various street classifications, in each case for a typical condition of street width, pedestrian volume and abutting property.

TABLE III

Street Classification	Average Footcandles	
	Between Curbs (Roadway)*	Curb to Property Line (Sidewalk)
Very heavy traffic	1.2	0.05
Heaviest traffic	1.5	0.05
Very light traffic	0.1	0.1
Light traffic	0.2	0.2
Medium traffic	0.4	0.3
Heavy traffic	0.8	0.4

*These values apply where the pavement has reasonably favourable reflection characteristics. Somewhat higher footcandle values should be employed where the reflection characteristics of the pavement are unfavourable.

Taking into account the added requirements usually imposed in business streets, the following table of illumination intensity values is developed out of the preceding table. The values in the preceding table are reproduced in this table in heavy faced type. The other derived values appear in lighter faced type. (See Table IV.)

Illustrative Arrangement

Each example shown in the following table illustrates one possible arrangement. In determining a street lighting plan, the arrangement which will accomplish the desired results in the most effective manner should be selected. (See Table V.)

Business Streets

The minimum level of illumination that should be provided on primary and secondary business streets should never be less than the average footcandle valuations specified for traffic thoroughfares which carry the same volume of traffic.

Residential Streets

The illumination on residential streets is primarily required for general protective and police purposes. Therefore, ordinarily it need not exceed 0.1 average footcandle on street and 0.05 on sidewalk surfaces. Due regard should be given to the obstruction of the proper distribution of the lighting by trees, shrubbery and poles, in designing the lighting installation. Better lighting results when trees are planted along the lot lines.

While aesthetic requirements, the presence of dwellings and other local conditions should be given due consideration in designing street illumination, adequate night public safety should not be sacrificed for these other factors.

TABLE IV—LUMENS PER SQUARE FOOT (FOOTCANDLES) RECOMMENDED FOR VARIOUS TYPES OF ROADWAYS CARRYING TRAFFIC OF VARIOUS DEGREES OF DENSITY.

	Very Light Traffic		Light Traffic		Medium Traffic		Heavy Traffic		Very Heavy Traffic	
	Avg.	Min.	Avg.	Min.	Avg.	Min.	Avg.	Min.	Avg.	Min.
Principal business streets	.....	.....	0.4	0.1	0.8	0.2	1.2	0.3	1.5	0.4
Secondary business streets	.....	.....	0.3	0.07	0.6	0.15	1.0	0.25	1.3	0.3
Through high-speed arteries (other than business streets)	.....	.....	0.3	0.07	0.6	0.15	1.0	0.25	1.3	0.3
Express freeways and viaducts	.....	.....	.....	.....	**0.4**	0.1	**0.8**	0.2	**1.2**	0.3
Residence streets	**0.1**	0.02	**0.2**	0.05	**0.4**	0.1	.....	.....	.....	.....
Industrial warehouse streets	**0.1**	0.02	**0.2**	0.05	**0.4**	0.1	.....	.....	.....	.....

Notes: The heavy-faced values appear in the earlier table. The other values have not been determined independently but have been derived from them.
These recommendations apply where pavement reflection characteristics are favourable, as in the case of light concrete or light-finished asphaltum. Somewhat higher footcandle values should be employed where street surface reflections are less favourable.
In situations where there is considerable pedestrian traffic provision should be made for adequate lighting of sidewalks.

STREET INTERSECTIONS

Studies have proved that more accidents occur at street intersections than at any other one location of our street systems and that the impairment of visibility by darkness greatly increases the hazards of traffic conflict at intersections. Therefore, the importance of providing adequate visibility at street intersections and approaches thereto cannot be over-emphasized.

In general it is recommended that the level of illumination provided at the average rectangular or diagonal street intersections should be at least equal to the sum of the illumination values herein recommended for the two streets which form the intersection.

While "T" intersections formed by the termination of one street at a through street, will not ordinarily require more illumination than that specified for the average rectangular intersections, it is essential that adequate indications should be provided to warn motorists of the termination of a street at that point.

BOULEVARDS AND PARK-DRIVES

The standard of illumination that should be provided for boulevards and park-drives in urban areas should be the same as the average footcandle valuations recommended for streets carrying the same volume of traffic.

TABLE V

Street Classification*	Lamp Lumens	Mounting Height (Feet)	Spacing Measured Along Middle Line of Street (Feet)
Very light traffic	1000	15	90 - 110 Staggered
	2500	20 - 22	130 - 170 "
	4000	25 - 30	200 - 250 Centre
Light traffic	2500	16 - 18	100 - 120 Staggered
	4000	20 - 25	130 - 170 "
	6000	22 - 25	130 - 170 "
Medium traffic	6000	20 - 25	100 - 120 Staggered
	10000	22 - 27	130 - 170 "
	15000	25 - 30	130 - 170 "
Heavy traffic	10000	24 - 28	75 - 90 Staggered
	10000	24 - 28	100 - 150 Opposite
	15000	24 - 28	150 - 180 "
Very heavy traffic	15000	25 - 30	100 - 150 Opposite
Heaviest traffic	15000	25 - 30	100 Opposite

*Because of greater street widths, larger lamps or closer spacings than shown usually are required on business streets to produce desired results.

Note: Among the foregoing the larger lamps or the closer spacings are appropriate on business streets.

Bridges, Overpasses and Viaducts

Bridges, overpasses and viaducts differ considerably in type, design, width, length and character of public use. Therefore, careful consideration should be given to the effect of all of these factors in determining lighting requirements for these structures.

The level of illumination should not be less than that recommended for streets carrying the same volume of vehicular and pedestrian traffic, or for streets of any other classification with which they connect. It is usually advisable to provide perhaps 25 or 50 per cent more light on these structures than that required for the connecting streets.

It is considered good practice to light the roadway abutments at both ends of a bridge, overpass or viaduct, thus indicating the abutments and bridge ends and the width of the roadway.

Underpasses and Tunnels

Effective illumination for long or low ceiling underpasses or tunnels resolves itself into night lighting, daytime lighting and several other important problems which affect the design, installation and operation of the lighting system.

The general level of artificial illumination provided in underpasses should be 50 per cent or more above the night illumination recommended for traffic safety on the connecting street.

The supplementary daytime illumination within the entrances must be of a relatively high order. It is operated only by day. Its purpose is to avoid the abrupt change in illumination from

several thousand footcandles of daylight outdoors to perhaps two or three footcandles inside the structure. Such an abrupt change produces seriously inadequate visibility just within the entrance.

Every practicable physical factor which will aid visibility within a tunnel or underpass should be employed. For example, use of dark-coloured pavement outside and light-coloured pavement inside the structure minimizes windshield reflections and reduces the range of brightness to which the eye must be accommodated during the daytime. In addition to the road surfacing, such aids to visibility as white centre strips, white curbs, light-coloured sidewalks and ceilings, should be incorporated.

The Measurement of Street Illumination Intensities

No presently available photoelectric cell photometers are adequate for the purpose as they suffer from inadequate precision even in the measurement of normal illumination or candlepower and depart from the cosine law in the case of light incident at acute angles.

Relation Between Street Lighting and Motor Vehicle Headlighting

Street lighting and motor vehicle lighting obviously are interrelated. The best interest of all the people is served by effective fixed lighting of traffic streets and of the more dangerous sections and most densely travelled stretches of highway. The resulting savings in accidents and property damage make such lighting economically sound and desirable.

Where there is a continuing flow of motor cars, and more especially where pedestrians must cross these streams of vehicles, the upper beams of headlights present a very serious hazard. In general, the use of only the lower or traffic beam should be permitted on lighted streets.

Driving with parking lights only involves a definite hazard to pedestrians on all but the very few streets which are lighted in accordance with the highest standards. Parking lights command insufficient attention to approaching cars.

The foregoing abstract sheds some light upon a matter that should concern every public-spirited person. Street lighting seems to be the first object of attention when reduction in civic expenditure is under consideration. During the early '30's street lighting expenditure was cut down by many cities and the number of traffic accidents was immediately increased. Conversely since then it has been found that fewer accidents invariably follow improvements in street lighting.

Hamilton Bustard, Kemptville

Hamilton Bustard, Commissioner, Kemptville Hydro-Electric Commission, died on Tuesday, July 29th, 1941, after several months' illness.

Mr. Bustard was born in County Fermanagh, Ireland, 66 years ago. He came to Canada as a youth, and for many years conducted a jewelry and optician business in Kemptville. He was interested in municipal affairs of the village and was for a time on the board of education. In January, 1926, he was elected commissioner of the local Hydro commission where he has served continuously until his death.

As a citizen of Kemptville he was well known and highly respected. He took a keen interest in outdoor sports and the work of fraternal organizations.

THE BULLETIN

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Hydro's War Service

By Dr. Thomas H. Hogg, Chairman and Chief Engineer, The Hydro-Electric Power Commission of Ontario

AT the outset I would like to make it clear that from the very beginning of the war, in fact before war started, the Commission realized that its contribution in this war could not be any part-time effort. It realized that in order to provide the necessary power and the necessary service for Ontario's war effort it had to re-organize its total effort on a wartime basis to meet any and all demands for electric service required by essential war industries.

Such planning presented difficult problems, because in the Fall of 1939 we had no conception of the magnitude of the task ahead of us. Many unfortunately were thinking in terms of 1914-18 and it was not until the fall of France in June, 1940, that the Nation realized the immensity of the task confronting it. In fact today, because this continent has not felt the immediate horrors of total war, there is still a large percentage of the population who fail to appreciate the imminent danger which the peoples of this continent and Great Britain face and which appears to be gradually closing in upon us.

However, I do not intend to dwell upon the military situation in Europe, but I would like to emphasize how important are our individual efforts towards the successful outcome of this war. Our jobs in this Hydro enterprise are to provide the motive power from which munitions of war can be speeded to the battle fronts where our fighting men are holding the Nazi invaders at bay.

We can, and are beginning to, make a great contribution in Ontario in providing the munitions and supplies so urgently needed in Great Britain and in Russia. In Ontario we have the most extensive electrical undertaking on this continent but, as I stated soon after the war started, it is not enough for us to supply power as, if

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From addresses given by Dr. Hogg before the Ontario Municipal Electrical Association, District No. 6 at Stratford on October 22, 1941 and District No. 7 at St. Thomas on October 24, 1941.

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Vol. XXVIII No. 10

OCTOBER, 1941

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

and when needed for war munitions; we all of us must insure that our valuable electrical power is used efficiently and to the best advantage in the manufacture of essential war materials. The Commission's engineers have already done valuable work in industry in giving advice on the efficient use of electric power to speed up the manufacture of war materials. Speed, and more speed, is today more urgently required than ever. Tanks, planes, and armaments of all kinds must be rushed across the Atlantic in ever increasing numbers.

Our primary duty, of course, is to provide and insure a continuous service to plants manufacturing essential war materials.

The duty of providing sufficient and adequate power resources in Ontario falls to the Commission and, as you know, the Commission made plans to insure this before war broke out, and at the outbreak of war redoubled its effort to strengthen its systems to insure that all the heavy demands for electric service could be met promptly. Today, after two years of war, the Hydro is supplying about one-half million horsepower, or approximately 25 per cent of its total output, for direct war production. You will realize, of course, that this additional war load, serving a wide and diversified field has demanded a large amount of new construction work, increasing the capacity of generating resources and of transmission and distribution facilities throughout the Province. It has necessitated careful planning by the Commission's engineering staff who had to anticipate demands months and years ahead of requirements.

During the first year of the war the Commission spent more than $11,000,000 in new capital construction, and this year ending October 31 it will have spent about $17,000,000.

Increased Industrial War Loads

The increased industrial load that has taken place since the war started is mainly attributable to the demand of large plants engaged on munition work and served by The Hydro-Electric Power Commission on behalf of the systems. Thus the estimated increase above peacetime requirements for the three southern systems, to December

1940 was 180,000 horsepower, and of December 1941 over December 1940, 270,000 horsepower, a total increase for the two-year period of no less than 450,000 horsepower. Of this amount about one-third is due to increased municipal load, and two-thirds to increased load of industries served direct by The Hydro-Electric Power Commission.

Up to December 1940 there had been an increase in surplus export of some 90,000 horsepower, but little additional surplus was available for export in 1941, as primary demands have used up all additional supplies as they became available.

With regard to the increased load of industries served by municipal utilities, it must be understood that manufacturing plants which have been switched to war work still utilize to a large extent the same mechanical and electrical equipment and, therefore, if they were working steadily before the change, did not increase greatly their power demand, but working longer hours their energy consumption is greatly increased. In round figures the percentage energy consumption increase is about twice the percentage increase in horsepower demand.

Electricity in Manufacturing

There can be no doubt about the value of electric power in the production of munitions and supplies, but few people realize the great advantage that Canada, and particularly Ontario, has in this regard.

Since the last war there has been a rapid evolution of power machinery in manufacturing and mining industries in Canada toward electric drive. With no coal mined in the chief manufacturing provinces of Ontario and Quebec, and with the large supply of water power within economic transmission distance of manufacturing and mining centres in these and in most other provinces, this trend has been more pronounced than in many countries. For example, in Canada at the end of the last war there was a total of about 1,000,000 horsepower in electric motors used in the manufacturing industries, but today there is a total of about 5,000,000 horsepower used in electric motor drives.

New Supplies of Power

Since the war started additional supplies of power have been secured by purchase under the Quebec contracts and by the construction of new developments.

When the war started in 1939 the excess capacity of the three southern systems—Niagara, Georgian Bay and Eastern Ontario—amounted to about 170,000 horsepower, and there was scheduled for future delivery under the Quebec contracts an additional 140,000 horsepower, or a total of 310,000 horsepower available for future growth. Under the schedule of deliveries the last block of Quebec power was not due until November 1944. Due to increased war demands however, it was necessary to advance delivery of certain blocks of power, and of the total of 140,000 horsepower scheduled in 1939 for future delivery, 90,000 horsepower has been taken in advance of schedule, and the remaining 50,000 horsepower from Beauharnois will be taken as soon as it becomes available next year.

Arrangements have also been made to purchase an additional 82,000 horse-

power from Maclaren Quebec Power Company; 57,500 horsepower of which is for the duration of the war.

Negotiations are also underway for the purchase of a block of power from the Gatineau Power Company on a short term basis.

On the Niagara river additional water diversion of 8,000 cubic feet per second has been obtained by negotiation with the United States Government. About 5,000 cubic feet per second of this additional water flow is in consideration of the additional water to be added to the Great Lakes by the Ogoki and Kenogami diversions. The additional water-flow has enabled the Niagara river plants to produce some 1,300,000 kilowatt-hours per day for munition production.

By purchase from Quebec and by using additional water at Niagara Falls, we have been able to add about 172,500 horsepower to the capacity of the Niagara system since the war started.

In the fall of 1940 we commenced the construction of two new developments.

For the Georgian Bay system a 10,000 horsepower plant at Big Eddy on the Musquash river was commenced. Exceptionally rapid progress was made on the construction of this plant, which was placed on commercial load this month, on October 11th.

In the Eastern Ontario system a 54,000 horsepower plant at Barrett Chute on the Madawaska river, and a storage dam in connection therewith at Bark lake, are being constructed. Good progress is being made also on this development, and it is anticipated that the first unit will be in operation on July 1, 1942.

On the Musquash river there remain two undeveloped power sites aggregating 15,000 horsepower. Development of one of these sites will be undertaken next year.

To provide for further primary growth on the Niagara system, construction was started last month on a new 25-cycle plant at DeCew Falls adjacent to the present 60-cycle generating station formerly owned by the Dominion Power and Transmission Company.

This plant will have an ultimate capacity of 200,000 horsepower under a head of 285 feet using approximately 3,500 cubic feet per second of water conveyed through the new Welland ship canal with improved local pondage.

Present plans, however, call for the installation of one 65,000 electrical horsepower unit operating at a head of 265 feet. It is expected that this plant will be ready for operation by the end of June 1943.

To provide sufficient water to operate this development at its ultimate capacity of 200,000 horsepower it will be necessary to use the water now being employed to operate the present 60-cycle development. It is expected, however, that when this time arrives the 60-cycle load will have been changed to 25-cycle operation.

Co-ordination of Power Supplies in Southern Ontario

To an increasing degree generating plants and transmission and distribution networks operated by the Commission on behalf of the three co-operative systems of Southern Ontario, namely the Niagara, Georgian Bay and Eastern Ontario systems, tend year by year to become linked together in so far as the

physical properties are concerned. Thus the Niagara system is linked to the Georgian Bay system by frequency-changers at Mount Forest and Hanover. It is also linked to the Eastern system by a frequency-changer at Chats Falls. These frequency-changers and their associated tie transmission lines are of sufficient capacity to permit interchange of substantial blocks of power from one system to another, so that diversity in the time of peak load, fluctuating energy requirements or variations in power supplies available from different power plants may all be co-ordinated to smooth out the demand curve to the advantage of the interconnected systems. Connections are also available to certain municipal and privately owned systems. This pooling of power resources in Southern Ontario reduces the amount of reserve plant required, and providing the tie lines and frequency-changer plants are of ample capacity, all reserve plant becomes available to any system.

The net practical result of this co-ordination of power supplies is equivalent to the provision of additional generating capacity in all three systems.

Freedom from Interruptions

It has often been pointed out that the Commission in constructing its power developments and transmission networks considers that the wisest, and in the long run, the most economical practice is to follow the policy of installing the best available equipment. A long record of freedom from serious trouble in its transmission lines fully justifies this policy.

Of course it is not possible to guard against every possible contingency. Recently, as you know, the three main transmission lines first constructed from the east, which for most of their length are on the same right-of-way, were subjected to a freak storm, commonly referred to as a twister, which within a few minutes and within a distance of less than half a mile destroyed towers on each of the three separately-supported circuits. The damage occurred at 4.45 p.m. on October 7th, about five miles west of the Cloyne road, directly north of Napanee.

As much as possible of the load was transferred to the fourth main eastern transmission line, which at this distance from Toronto is far to the south. In fact we are able to transmit on this line about 50 per cent more than its designed capacity. It took some time of course to locate the breakage and to transport the necessary emergency equipment to the spot, which was reached a little after midnight. By clearing away the debris, including the broken towers, the emergency squads were able to restore service on one line just at daybreak.

Continuing their labours they were able by erecting temporary wooden structures to restore service on the second line the same afternoon. Permanent repairs were immediately started on the third line, and within a week spare towers had been erected and service was fully restored on all three lines.

I would like to explain here that it would be economically unsound to build towers on our lines strong enough to stand up against freaks of nature, such as twisters. Towers could be built strong enough, but you can imagine their appearance. They would have to be very heavy in construction and would cost perhaps five or six times the pre-

sent cost. No one would advocate paying five or six times their cost in order to protect the Commission's service from an interruption that may occur only once or twice in a lifetime.

Efficient Utilization of Hydro Service

One means of avoiding wasteful use of electricity is to assist consumers to make the most efficient use of their Hydro service. The work of the Sales Promotion department of the Commission was, therefore, modified during the past two years to meet the changed conditions imposed by the war. A large number of factory inspections were made and special engineering reports prepared to assist plants producing war materials to operate more efficiently. This engineering advisory service, which dealt with improved lighting, motive power and heat treatment, was welcomed and used to excellent advantage by many industrial organizations throughout the Province. In the rural field effort was made to foster the use of electricity on the farm in ways that would release manpower and enable the farmer to produce in greater volume at lower cost.

I do not think I need urge that officials of the local Hydro utilities co-operate with their local industries to make sure that Hydro service is being effectively used in the channels of war production to improve quality and increase output of essential materials.

Restrictions in Power Consumption

Towards the end of the last war the Commission was supplying more than 186,000 horsepower for the manufacture of munitions. Of this amount 30 to 35,000 horsepower was off-peak power. A serious shortage developed and drastic steps were taken to relieve the shortage. The various municipalities were at that time able to adjust their consumption so as to reduce the load on-peak by from 20,000 to 30,000 horsepower.

Up to the present there has been no necessity for drastically curtailing the use of electricity, but the Commission's engineers have been studying ways and means for conserving our electric power resources when the time comes.

The chief adjustment so far made during this war to reduce the demands of the municipalities, has been the adoption and extension of daylight-saving time. By staggering the hours of peak load in this manner it is estimated that during the winter of 1940-41 a saving of about 80,000 horsepower at peak was effected. A similar or slightly greater saving will result from the same cause during the present winter.

Another step taken to check the increase in the municipal load has been the prohibition of the sale of new water heaters. In this connection certain municipalities are equipped with means of cutting off the flat-rate water heaters during the peak load times of the day.

Several other means of restricting growth in load or making actual savings in present consumption are available, such as the reduction of the hours of street lighting, eliminating display signs, cutting down store window lighting, prohibition of the sale of air heaters, the use during short peak load periods of auxiliary gasoline, Diesel or steam plants. During the last war a campaign was conducted through the daily press

and by means of other agencies to induce the public to reduce their demands by various methods.

At the present time we are not in a position to announce which, if any, of these methods of power conservation are or will be needed. We do not expect to have to impose many of these restrictions this winter. So far as the ordinary citizen is concerned, he may continue to use electricity as required in accordance with his usual practice. Nevertheless. and especially during the early winter evenings from November to February, he should avoid waste and extravagant use of electrical energy. If the domestic consumer will conscientiously exercise reasonable economy and be guided by instructions which will be issued from time to time by The Hydro-Electric Power Commission and his local commission, it is hoped that drastic curtailment in any particular form may be avoided.

Rural Electrical Service

One of the ways in which the Commission's programme must now be modified is in the matter of extensions to rural electrical service. For some years prior to the depression, and indeed up to 1931, there was a notable increase in the growth of electrical service in the rural power districts of Ontario. During the depression this growth was curtailed, but since 1936 extensions to rural electric service have been phenomenal, and the aggregate peak load in rural power districts has more than doubled. So successful indeed has this programme of extension been that the Commission estimates that more than 80 per cent of rural citizens living within economic transmission distance of Hydro sources of supply are now being served with electricity by the Hydro, or have Hydro lines adjacent to their property. It is estimated that by the end of 1941 more than 20,000 miles of rural primary lines will have been constructed to serve no less than 130,000 rural consumers. The capital expenditure on these lines and equipment will have reached $39,000,000, towards which the Government by grant-in-aid will have contributed $19,500,000.

It is fortunate indeed that such good progress was made in rural electrification during the past few years, because the Commission, much to its regret, is forced by the war demands to eliminate further rural extensions, except of course where they are made to serve war industries, flying fields, etc. The few extensions now underway will be completed. As indicative of the causes which render it necessary to suspend new construction, it may be stated that Canada has to import for the manufacture of rural transformers a special type of silicon steel not made in Canada, and it is necessary to conserve such supplies as are still available for the maintenance of existing lines. Priorities respecting the use of all steel, copper and aluminum for war purposes also affect the situation. The action with respect to the extension of rural lines is in conformity with a ruling of the Dominion Power Controller.

Conclusion

Finally I would urge upon you the necessity of not being misled by the apparent ease and smoothness of our economic life in Canada to-day. No little credit for this state of affairs is due to the steady functioning, day-in and day-out, of our electric supply sys-

tems throughout Canada. Far removed from the present actual theatre of war, Canada for the past two years has been reaping the benefits of the great growth in hydro-electric development and the concurrent growth in her manufacturing facilities that has taken place since the last war. This growth has been greatly in excess of peacetime home consumption requirements, and has enabled us during the past two decades to become one of the great exporting nations of the world. We could, therefore, enter upon a war construction and munitions manufacturing programme of considerable magnitude, and advance a long way upon this path, without noticeably restricting the production of consumer goods for our own people. But there are evidences on all hands that this state of affairs is coming to an end, and that from now on every move we make as individuals and as citizens of the Empire will have to be evaluated in the light of the question, "does this proposed action contribute to the war effort of Canada?"

One more point. You men, who are Hydro Commissioners, I am sure fully realize the part being played by Hydro in this war. But I think you will agree that it is difficult to inform the public about our operations because they are so large, so widespread and so complex.

We are handling a product that is used in all urban and most rural homes, but it is only in time of trouble that our service, or rather lack of service, is brought into the limelight of public opinion.

Furthermore, when we have to make some decision for the benefit of the majority, such a decision may possibly be to the detriment of a minority. We may not, therefore, be able to please all the people all the time.

I am, therefore, going to suggest to you that you should, as Hydro Commissioners, familiarize yourselves with Hydro's operations and then *champion* Hydro in your own communities. And if there is ever anything you do not understand or want to know about Hydro either write to us—or better still come and see us. My door is always open.

Precautions During Storms

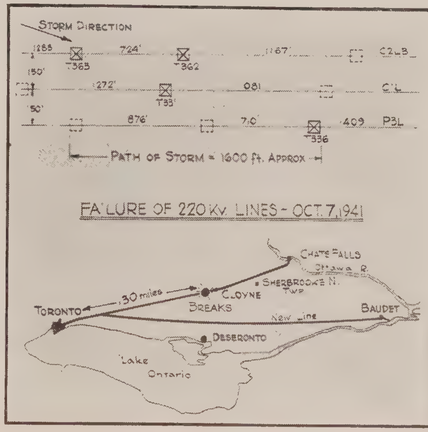
Dr. P. L. Ballaschi, Westinghouse engineer, has drawn the following conclusions from a survey of more than 100 lightning fatalities. First and most important, get under a shelter as quickly as possible. Houses, barns and other buildings—the bigger the better—are good shelters. The top and sides of buildings will usually provide a better conductor path than the human body for lightning to reach the ground. When a storm threatens, keep off golf courses, suspend outdoor games, don't ride bicycles, or horses and don't operate exposed machines such as tractors. Avoid shelter under trees, particularly isolated trees. Stay away from poles, masts, and other exposed objects projecting skyward. Stay in your car if an electrical storm suddenly develops while you are motoring. About 90 percent of lightning casualties occur in rural districts and open spaces where the exposure hazard is greatest. Barns, farm houses and structures located on the outskirts of cities are made safer by the erection of lightning rods.—*Journal of Applied Physics.*

Freak Storm in Eastern Ontario

THE facts of the freak storm which attacked three Ontario Hydro 220-kv. lines serving metropolitan Toronto district from the east are as follows:—

On the afternoon of October 7th, when there appeared to be fairly settled weather conditions, fair winds or gales were blowing in different parts of the province; however, no one seemed to be inconvenienced. In the course of the afternoon, a patrolman located along the 220-kv. system north of Belleville noticed a small, more than usually dark cloud moving from north to south some distance east of his station. Although this occurrence was noticeable and somewhat unusual, it did not impress him sufficiently to warrant a telephone report. There was no evidence of a tornado funnel or the like; however, delivery of power over one route of three single circuits from the east to metropolitan Toronto was presently interrupted.

On examination during the night of October 7th, it was found that considerable physical damage had been done to the three 220-kv. lines and the telephone circuit on this route. The destructive path of the storm was very narrow, was generally along the transmission line route, and was quite local. The path was from 100 to 200 feet wide and apparently did not extend great distances into the second growth scrub timber on either side. It was followed on October 8th not more than 100 feet into the bush on either side of the line and for a distance of about 2,000 feet along the 450-foot cleared strip. Where it did extend into the timber on the north side of the right-of-way, very many six-inch birch and poplar trees were found in one area felled generally towards the east. In another area, not more than 200 to 300 feet distant, another group of 16 to 20 trees was found lying generally in the opposite direction. Through the path across the right-of-way there were extraordinary occurrences such as the following.



Sketches showing locations and relation of storm path to the towers of the three circuits.

Two towers were collapsed in the north 220-kv. line, one in each of the other two lines, and the telephone conductor was severed, with one pole lost. No conductor or other cable on the three 220-kv. circuits was severed. The aluminum covering of some of the conductors of one 220-kv. circuit was stripped, only one tower head moved along line so that it was about as long lying on the ground as when in the air. The other three towers collapsed vertically, having been held by the con-

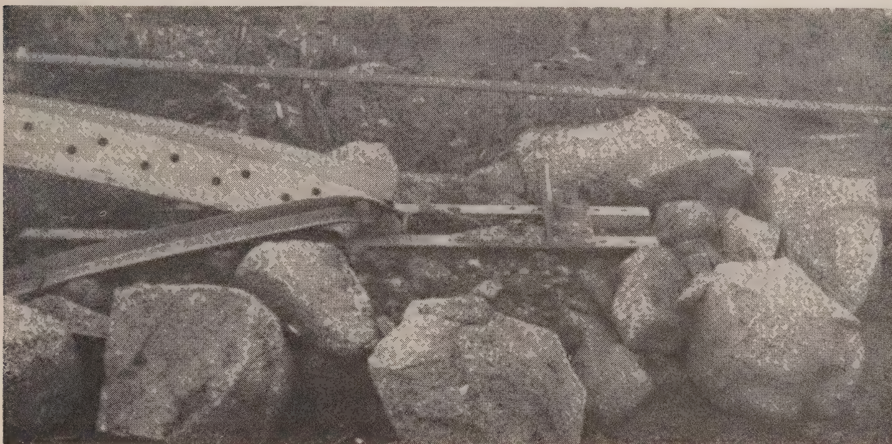
A heap of twisted wreckage was all that was left of this 220 kv. tower.

ductors. The conductors had practically, dropped vertically. Men and materials were available and were at the quite remote site within an hour after the failure was located.

Service on one of the three circuits was restored during the night, and on the second circuit late in the afternoon of October 8th. New towers were erected for the northerly circuit in the course of the following day.

The four rock foundations were not appreciably disturbed. The anchor bolts and steel foundation channels at one corner of the tower which was lying stretched along line were moved easterly slightly. Restorations were made by re-aligning the anchor bolts.

"Bird-caged" aluminum, indicating where clamps had slipped along conductors.



Foundations, in practically all 16 cases, were intact and usable. One was adjusted.

During the course of this disturbance, load dispatching and system stabilities were major problems for the operating engineers. Once control was secured of the customer demand, the system settled down with a fourth new 220-kv. line (from Beauharnois), which was not involved in the local storm, carrying 360,000 horsepower, a considerable overload from any operating engineer's point of view. This line is reported as having been only momentarily in trouble, twice during the period, once because of lightning near Beauharnois, and a second time apparently because of instability.

On the morning of October 8th, it was possible to observe some extraordinary physical conditions in the storm path. Many stones, weighing 25 to 50 pounds, had been picked up out of their natural location, carried 20 or more feet, and left lying on the sod; one steel tower member, several feet in length, was found lying in moss some 1,200 feet from the collapsed tower. It had been torn loose at each end. It carried one bolt.

A few larger stones, weighing 75 to 100 pounds, were turned over and moved about, The telephone pole referred to as lost was found in the bush

A 25 ft. by 9 in. telephone pole, with crossarm and insulators still attached through the lag screw of the braces, as found in the standing timber adjacent to the 450 ft. cleared strip.

Freshly turned earth where the wind had an opportunity to create a furrow at a rock outcrop.

some 400 to 500 feet removed from its location.

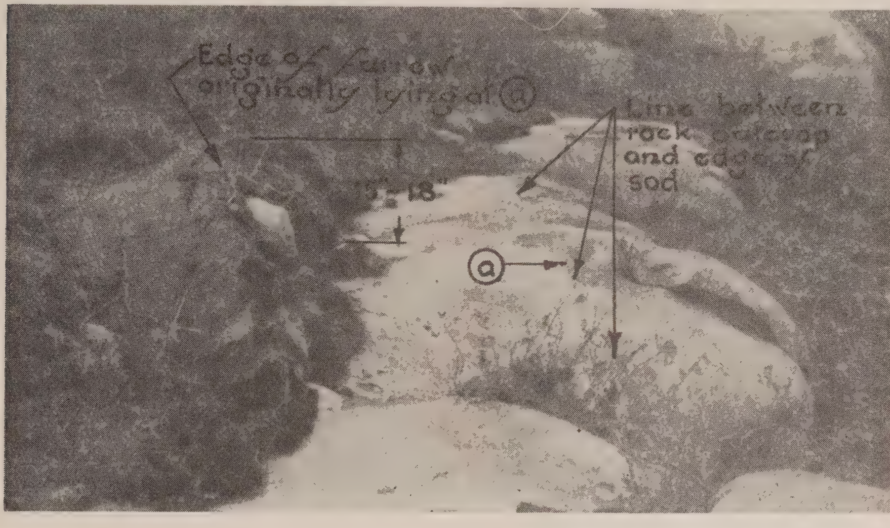
A more careful examination at the site and a review of the local press brings out two interesting items.

The storm path appeared to be travelling from west to east in the vicinity of the structural failure. On climbing the transmission towers, the storm path could be recognized removed some 300 feet from the right-of-way. It could be followed paralleling the lines for about 2,500 feet west of the point where it crossed. It had cleared a path of standing timber some 100 to 200 feet wide including large pine trees.

Photographs are included which indicate how, at the centre of the path when crossing the transmission line route, earth was ploughed at rock outcrops. One photograph shows earth turned over as a furrow some three to four feet in width and indicating heights of 15 inches with large rocks included in the turnover.

So far as can be checked there was only a minor difference in the time of another "bounce" which was reported in the local press some 20 miles east where farmsteads and agricultural developments were seriously affected. *The Perth Courier* of October 16th reports the story in a half-column article, including the following—

"There (lots 5, 6, and 7, concessions 1, 2, and 3, respectively, of Sherbrook township) roofs were blown off barns, cow byre, horse stable, etc.; hay stored in barns may have to be stacked; two stacks of hay were blown completely away, some of the hay lodging in trees on a farm six miles distant; a garage was whisked away and smashed to kindling; an auto was dumped on a rock pile a hundred feet away and completely wrecked; one section of the



The smooth surface, some three feet long to the left of the rock sticking out of the 15 to 18 in. elevated earth, is the extent of this particular turn-over near the centre of the storm path.

car was found a half mile away from where the car was sitting when the storm broke; . . . shade trees of spruce, balsam and maple, large enough that a man could not put his arms around one of them were uprooted or snapped off a few feet above ground; the house was jolted out of position on the foundation. . . .

"The storm . . . . snapped to the ground a pathway of trees fifty feet wide through the centre of a sugar bush, levelled the sugar-making house, and moved a residence slightly out of position on its foundation.

"The storm seemed to descend to earth much as would a bouncing ball, landing here and there, and doing terrific damage where it struck, then lifting and passing over adjacent properties; path of the storm varied from about fifty to about one hundred feet in width.

"Huge rail fences were removed completely; the rails . . . . were carried high into the air and were forced back to earth with such velocity as to be driven several feet into the ground, so far that a team of horses was required to pull any one of them out . . . ."

O. M. Perry, Windsor

On the evening of Friday, October 24th, 1941, Oliver Mowat Perry, Manager of the Hydro Division of the Windsor Utilities Commission, died suddenly at his home in Windsor, aged 56 years.

"O. M." was born at Cloyne in Frontenac County, Ontario, and attended school in Perth, following which he taught school for a short while. He then went to Queen's University and after graduation entered the shops of the Canadian Pacific Railway at Montreal. Shortly after he came to Toronto, where he was employed in the Engineering Department of the Toronto Electric Light Company, Limited for one and a half years, later going with Smith, Kerry and Chase on the Central Ontario system.

When the Windsor Hydro Electric System was started in 1913 he was made manager in charge of planning and construction of distribution within the city preparatory to receiving power through the Hydro, as well as its operation after it was put into service. Later on the formation of the Windsor Utilities Commission he was made manager of the Hydro Division. Windsor contract was for 2,500 h.p. In 1914 when power was first taken the load was 590 h.p. Since that time the growth of the Windsor load has been such that for 1941 it will be well over 44,000 h.p. This is but a reflection of the faith he had in his work and of the utility of which he was a champion from its very inception.

Mr. Perry was closely associated with the community life in Windsor and deeply concerned with the city's welfare. He was widely known and highly respected in Hydro circles throughout the province, taking an active part in the Association of Municipal Electrical Utilities on whose executive he served for a number of years, being President in 1935. He was holding the office of Chairman of the A.M.E.U. Merchandising Committee at the time of his death.

An enthusiastic golfer, few men enjoyed the sport more than he. It was his chief recreation, playing late and early, only the heavier snows of winter keeping him off of the course. He was proud of his membership in the "Hole-in-One" Club for which he qualified in December, 1927.

His engineering ability was recognised in all his contacts with the Commission's staff, while his wonderful per-

sonality and ready co-operation resulted in his widespread popularity among the Hydro utilities and in other walks of life.

L. A. Foulds, Paris

Louis A. Foulds, Commissioner of the Public Utilities Commission of the Town of Paris passed away on Saturday, October 4th, 1941, following a short illness.

Mr. Foulds was born on a farm in Brantford township near Paris forty years ago and attended Paris public and high schools. For a time he farmed near Glenmorris but in 1928 went to Paris as an automobile salesman. He became manager of the business and after a time took it over, naming it Paris Motors, Limited. He was an aggressive business man and a successful executive.

He was active at all times in furthering the best interests of the town and was for several years a councillor. In 1938 he was elected commissioner of the Public Utilities Commission, where he has served continuously until his death.

We regret very much the loss of Mr. Foulds and feel that the Paris commission, as well as the town, has been deprived of a very valuable and useful citizen and official.

Why Rural Consumers Get Mad

The prevalence of starlings in Ontario has been causing an increasing number of interruptions to rural lines, particularly where voltages exceed 2300 volts to ground. These interruptions vary all the way from minor interruptions involving one transformer and one con-

sumer to major interruptions affecting large areas, much to the annoyance and inconvenience of the consumers.

"Bird Trouble" is most pronounced when birds are gathering in flocks toward the end of the summer.

The illustration shows what happened to a starling when it got too chummy with both ends of a cutout insulator at the same time. The insulator broke when the short occurred and so did the bird. No interruption occurred as the fault current did not go through the fuse and the insulator separated sufficiently at the break so that it was not affected by rain. In other words, the porcelain insulator was replaced by air insulation.

International Plowing Match

THE International Plowing Match and Farm Machinery Demonstration of the Ontario Plowmen's Association was held this year October 14th to 17th inclusive on the farm of R. T. Lillico, approximately five miles from Peterborough.

Rain was experienced on the first day of the match which seriously curtailed the attendance. The remaining three days however, were bright and clear and resulted in an excellent attendance which was estimated at 95,000.

There were 641 entries in the plowing contest which took place convenient to the headquarters area.

The concession area covered 12 acres of land and provided 4,500 feet of frontage for exhibits. The electrical distribution system required the erection of some 2,500 feet of primary and secondary bus serving 68 exhibitors with a load of 87.4 kilowatts. The water supply was obtained from the city of Peterborough by means of a tank truck and was pumped from a 1,000-gallon storage tank through approximately 1,100 feet of pipe with hydrants conveniently located to the caterers' tents.

The farm machinery exhibit was more extensive than at previous plowing matches and the keen interest taken in the mechanical equipment demonstrated, including electrical equipment for the farm, particularly milking machines, reflected the serious labour problem being experienced by many farmers, particularly those in the dairy industry.

Among the interesting features of the match was a demonstration by a detachment of the Royal Canadian Artillery from Petawawa who demonstrated the ability of the modern gun tractor to negotiate difficult terrain. A detachment of the Royal Canadian Engineers from Petawawa also gave a demonstration of the construction of a temporary derrick which attracted large audiences twice a day throughout the match.

On Friday afternoon the Plowmen's Association was honoured by a visit from His Excellency, The Earl of Athlone, Governor General, and Princess Alice, who took a very keen interest in the contests and other features of the Plowing Match.

The Hydro-Electric Power Commission trophy was won by Russell Watson of Woodbridge.

Exhibit in the Hydro tent.

The H.E.P.C.'s exhibit was housed as usual in a large tent and consisted of representative pieces of electrically driven farm equipment; such as, milking machines, separators, brooders, grain grinders, pumps, etc.

One new item in the farm section that attracted considerable attention was the pig brooder manufactured by J. R. Dean, Superintendent of Wheatley Hydro-Electric System, Wheatley, Ont., and if the enquiries and interest shown in this item were any indication of the need for this piece of equipment it should not be long before it is successfully established as an essential piece of farm equipment.

The display of appliances for home use was considerably reduced this year owing to the difficulty in obtaining suitable merchandise for display.

Modern electrical transcriptions, such as millions listen to everyday on the radio, played an important part in attracting large groups to our exhibit. The record carried a breezy, educational conversation between a typical young farm couple, Tom and Mary White and their older friend, Joe Brown—during the course of which Mr. Brown thoroughly convinced his young friends that Hydro powered milking machines, coolers, grain grinders and similar equipment are the answer to the war-time labour shortage problem. The characters were played by a group of well-known Toronto radio performers.

The Dark Winter Mornings

DURING the winter months, one frequently hears remarks regarding the darkness of the mornings. With daylight saving time in effect, the mornings seem unusually dark and sunrise very much delayed. In the latter part of December, this is particularly noticeable, for sunrise is gradually later while the evenings are lengthening until, in January, the sun is just rising as we are travelling to our offices but there is still about an hour's sunlight after the offices close.

The darkness of these mornings depends, of course, upon the cloudiness of the sky as well as the time of sunrise. The former is not predictable over any appreciable period, but sunrise, and also sunset, recur regularly from year to year with the seasonal variations definitely known.

The times of sunrise and sunset at any given point on the earth's surface depend upon several factors, namely:—

(a) The earth's orbit being an ellipse instead of a circle, results in variations in the angular velocity of the earth around the sun. Sometimes, on this account, the sun would be ahead, and sometimes behind its yearly average time in crossing the meridian. This affects sunrise and sunset by a small amount both being later than average from January to June and both early from July to December.

(b) The earth's axis being inclined to to the plane of its orbit causes further variations in the sun's crossing of the meridian and this is a two-cycle-per-year effect whereby the sun is late from the winter solstice to the vernal equinox and also from the summer solstice to the autumnal equinox, i.e. respectively from December 22 to March 21 and from June 22 to September 21. The sun then would be early during the intervening periods, namely from March 21 to June 22 and from Sept. 21 to December 22, these dates being closely approximate.

(c) The inclination of the earth's axis also is the cause of the wide change in proportion of day and night giving the long summer days and the long winter nights, these both becoming greater for the higher latitudes until at the poles there are the continuous summer day with the midnight sun and the long unbroken winter night with the sun always below the horizon. Sunrise and sunset, therefore, vary according to the latitude of the point of observation.

(d) The longitude of the point of observation, in relation to that of the standard meridian for the time zone being considered, is yet another factor. For westerly points in the zone, sunrise and sunset are later than for easterly points in the same zone. This effect is due to the convention employed in marking off the time zones and choosing the standard meridians as the bases for reckoning time.

(e) The additional hour for transferring from standard to daylight saving time is also a convention and

gives the effect of both sunrise and sunset occurring one hour later than they do by standard time.

The central reference point for the city of Toronto, the Meteorological Observatory on Bloor St., has Latitude of 43° - 40′, North, and Longitude, 79° - 24′, West of Greenwich. The times of sunrise and sunset for the winter months at this point are given by the accompanying respective curves A and B. These curves show how the winter mornings gradually darken until about January 6 but the evenings begin to lengthen about December 12.

It will be seen from the foregoing discussion that the times of sunrise and sunset, as stated in daylight-saving time, depend upon five factors, three of which are natural and two conventional, the latter, of course, being matters of convenience. Usually, where a number of factors contribute to one result, it is interesting to analyze these factors and note their individual effects. The accompanying graphs give a partial analysis in this case, as follows:—

If the earth's orbit were a circle and its axis perpendicular to the plane of the orbit, day and night would be equal, twelve hours each, on all parts of the earth, though possibly some confusion would arise at the poles. In this case, by Eastern Daylight Saving time based on the 75th meridian, the sun would rise each morning, at Toronto, at 7 hours, 17 minutes, 36 seconds and would set each evening at the same hour by the clock, as shown by curves C and D, giving the twelve-hour day, and equal night, without variation.

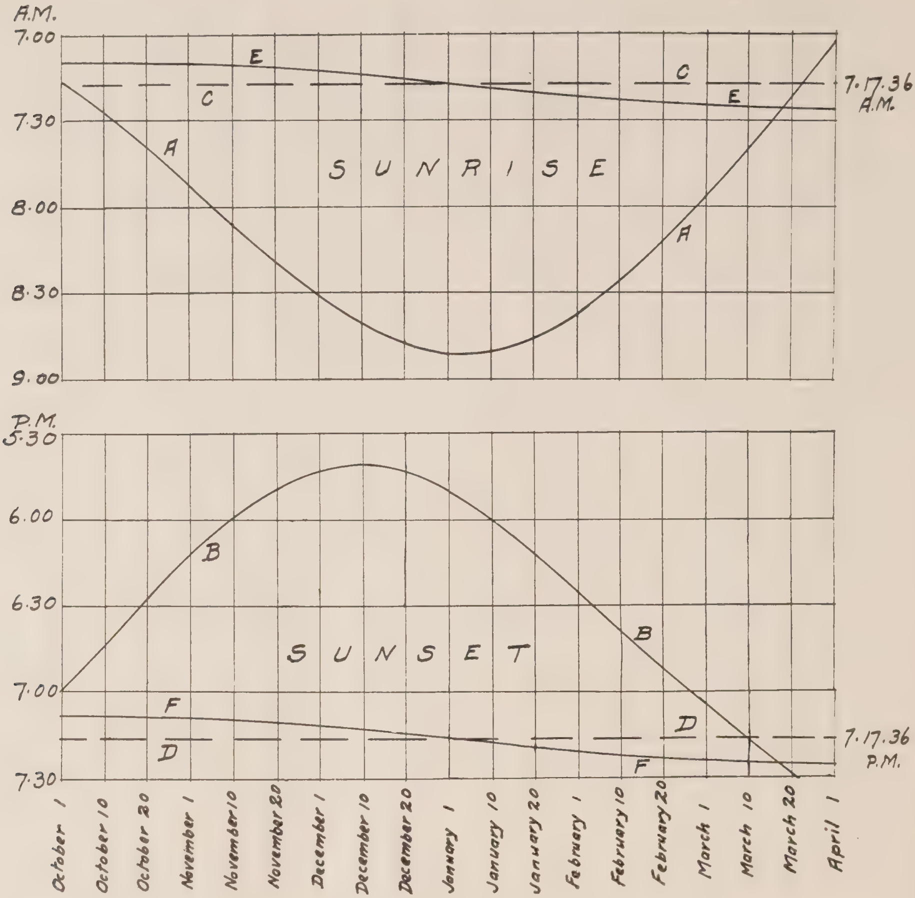
With the earth's orbit an ellipse, as it is, but again if the earth's axis were perpendicular to the plane of its orbit, small variations would occur in times of sunrise and sunset but the variation in the length of the twelve-hour day would be inappreciable, as shown for the winter at Toronto, by curves E and F.

The inclination of the earth's axis, causing both the two-cycle-per-year variation in the sun's crossing of the meridian and also a wide variation in the proportion of day and night at Toronto, is the chief factor in determining the times of sunrise and sunset here.

When these three factors,—orbital motion, inclination of axis, and latitude,—are combined, the resultant curves A and B, for sunset and sunrise at Toronto, are obtained. Their positions on the vertical scales of time depend upon the conventional factors of longitude, standard time zones, and the daylight saving additional hour.

It will be observed that the curves of sunrise and sunset, curves A and B, are offset horizontally with respect to each other. This is the result of the combination of the two factors, orbital velocity and axis inclination, the effects of which do not coincide on the average line at any time during the year, and both are cumulative, downward, during December and January to delay both sunrise and sunset. It is the rapid lengthening of the day which overcomes this delay in sunrise about January 7 and causes it gradually to recede, or become earlier.

The sun crosses any given meridian midway between sunrise and sunset on that meridian no matter at what latitude the point of observation may be. In summer, daylight will be longer, and in winter, night will be longer, the farther north from the equator the ob-



Sunrise and sunset at Toronto, Eastern Daylight Saving Time.

Curve A—Sunrise through the winter months.

Curve B—Sunset variations.

Curves C and D—Yearly average at Toronto. Sunrise at 7 h. 17 m. 36 sec.

Curves E and F—Sunrise and sunset if the earth's axis were perpendicular to the plane of its orbit,—i.e., if variations were due to orbital velocity only.

server is located. The resultant of the earth's orbital motion and inclination of axis will determine the centre of each solar day, and the year is so adjusted to the effect of the "wobble" of the earth's axis, known technically as "the precession of the equinoxes", that the seasons will remain in place. The accompanying graphs, therefore, will apply, without change, to winter conditions at Toronto for a long period of years.

The Electric Utility in Canada

By Wills Maclachlan

LET there be light. Down through the ages has come this cry. Primitive man seeing the sun rise and dispel the darkness, seeing the moon give light at night and a forest fire light up the countryside, endeavoured to make light himself so that at night he could see and in the dark caves could carry on at his work. The torch, the lighted faggot, the wax candle, the oil lamp and the gas jet served his purpose to a limited degree but man was always searching for something more satisfactory. To assist him in his work he domesticated animals and by the lever, the wedge, the roller and the wheel, endeavoured to relieve himself of physical labour. Later, by using the power of running water and, much later, that of steam, he was able to gain leisure from his labours and rise to higher achievements.

It is difficult for us today to realize that it is only within a comparatively short period of time that the practical application of electrical power has made available those many aids to our modern life that we call necessities.

Men working through all ages have been gathering facts and with these facts have endeavoured to interpret the laws of nature and apply them to their own purpose.

In 1791, there was a baby born into a blacksmith's family in England. He was Michael Faraday. As the boy grew up he was apprenticed to a book binder, and later came under the notice of Sir Humphrey Davy. He was appointed as an assistant in the laboratory of the Royal Institution of Great Britain and during the Thirties of the last century carried out investigations which so clearly developed, resulted in his report of 1841. His findings might be simply expressed as follows: a wire moved in front of a magnet has a current of electricity induced in it; a wire through which a current of electricity is flowing, placed near a magnet, moves.

In 1818 James Prescott Joule was born near Manchester. As he grew up he became interested in scientific research and, inasmuch as he had independent means, owning a brewery, he could devote time and energy to the development of his researches. The discovery having been made that a wire or a fine filament of carbon was heated by a current of electricity flowing through it, he formulated, in 1840, a quantitative statement of the law according to which heat is produced in a wire by the passage of an electric current.

Just prior to the time of these statements James Clerk Maxwell was born in Edinborough. He was educated in Scotland and later held professorships in Aberdeen and London and was the first Cavendish Professor in Cambridge. Among the many great things he did in his life, possibly his mathematical interpretation of Faraday's work was among the most far-reaching.

There is no doubt that in any outstanding interpretation of the laws of nature the work of many men is found. It might also be likened to the building of an arch, and in the arch that

Presidential Address to the Royal Canadian Institute, at Toronto, November 2nd, 1940.

is the foundation of the electrical industry of today, we find the triple keystone placed by Faraday, Joule and Maxwell. And out of their work has come the generator, the motor, the incandescent lamp and all of the heating appliances from the simple domestic iron to the huge industrial heating furnaces.

We turn now from the physicist and worker in pure science to those who have adapted the truths that have been found and in the electrical industry the name of Thomas Alva Edison looms large. Born in 1847, he started to work at the age of 10 and at 15 years of age was a telegraph operator. It is not my intention to trace the work of Edison in his many researches and developments at Menlo Park, except to point out that in his perfecting of an incandescent lamp on October 21st, 1879, and in his development of a direct current generator, he laid the foundation for a tremendous industry. It is only fair to point out that, almost at this time in England and independently, Sir Joseph W. Swan developed an incandescent lamp, but this does not detract one iota from the importance of the work of Edison. The problem then was to make use of this development. Instead of having small generators placed in each factory or each residence, the idea was conceived of placing the generators in a central station, carrying the wires through the streets and serving electricity into factories, stores and residences to be used in the incandescent lamps. It seems simple today, but looking back to those days one must remember that there were no cables, practically no electric wires, no underground cables, no switches, no fuses and no meters. The whole of the electrical industry has been developed since that time. Edison's first work was carried out in New York city. A central station was constructed on Pearl street. Underground conductors were made by placing two copper rods of semi-circular cross section in asphalt, in a pipe. Between these rods were placed two small wires. These sections, measuring about 20 feet long, were joined together by copper castings which were covered with asphalt in a box. And so the cable was made and laid in the streets and houses and stores connected to it. The two small wires were connected to the rods at the end of the cable and to a voltmeter in the power house. This was done so that the operator could tell the voltage at the end of his circuit and compensate for it. I hold the original of this cross section in my hand. Crude, but this was in 1881 and the first installation of the Edison two-wire system, installed under the personal supervision of Edison. The Edison three-wire system was still long in the future. The Pearl Street station was opened for service on September 4th, 1882.

Acting independently of Edison and working in England was a young man Sebastian de Ferranti, who was born on April 9th, 1864. Instead of working with direct current, Ferranti worked along the line of alternating current and in 1878 designed an alternator and patented it in 1882. In some of this development he worked with Lord Kelvin. In 1886 he was engineer for the Grosvenor Gallery Company and later with the Electrical Supply Company of London, England, and developed a distributing system, using underground cables at ten thousand volts, alternating current.

One is tempted to go down the many byways that are presented by the works of Tesla, Stanley and Westinghouse but I would rather draw your attention to a young man who was born in Newark, N.J., on February 12th, 1860—John William Lieb. He had been educated along scientific lines as a mechanical engineer and was first employed as a draftsman and later as first electrician of the Edison Electric Illuminating Company of New York, being in charge of the Pearl Street station. In 1883 he was sent to Milan, Italy, to install the Edison system, and while in Europe investigated the alternating current system, particularly the transformer which had been developed in Vienna, and strongly recommended to Edison that this system be adopted. The direct current system is limited to the voltage of the generator, whereas in the alternating current system the most suitable voltage is chosen for the generator. A transformer then increases this voltage to the most suitable for transmission or distribution and transformers placed at the point of consumption, reduce the voltage to that suitable for the consumer. Today the alternating current system is in universal use. However, those connected with Edison at this time were so wrapped up in the details of the direct current system that Lieb's advice was not followed.

One interesting story told many times by Mr. Lieb was that while he was in Milan attending an opera at La Scala, he was called out, as some of the street lights were not working, and in opera cloak and silk hat climbed the pole and made the necessary repairs. Later, John Lieb was to be the guiding hand of the New York Edison Company as First Vice-President and General Manager and, during the last war, was recalled by the National Electric Light Association, the then National Association of Electrical Utilities in the United States, to be their war time president. It is my humble opinion that John Lieb probably did more to develop the electric utility in the United States than any other man and he did much to present the personality of Leonardo Da Vinci to the American public.

The development of the modern electrical utility has gone through various stages. First—small plants because of limited voltages served small communities. With increase in voltage and the adoption of alternating current, larger communities were served. The increased transmission voltage made possible the development of large hydraulic power plants and the transmission of the power great distances to industrial centres and led to the huge networks of today. This development in Canada we will trace and see that men as well as scientific laws and machines go to make up the electric utility.

In the early 1880's many reports of the astounding advances in the development and use of electricity appeared in the press and Edison generators were installed in some of the cotton mills and other industrial establishments. At Pembroke, Ontario, there was a grist mill run by water power and owned by W. V. McAllister. An Edison generator was purchased, wires were run on the streets of Pembroke and service to the stores, residences and streets began on October 8th, 1884. Up to this time there had been installations of arc lamps in various parts of Canada, but this, as far as can be learned at the present time, was the first of what we might call an electric

public utility operated in Canada. Installation was made by Ahearn and Soper of Ottawa. In 1889 the Pembroke Electric Light Company was organized and has operated continuously from that date to the present. There was continued development here. When they found that the steam plant installed in 1893 was not big enough, a hydraulic plant on the Black river was installed and more recently a Diesel engine as a reserve. It is interesting to note that the present manager, J. A. Cone, started with this company in 1887 and has been continuously employed with them since that date. One cannot mention the Pembroke Electric Company without giving great credit to the late Hon. E. A. Dunlop for the strong guiding hand that he had in developing a utility in Pembroke adequate to the needs of the community and maintained according to the highest practices of the art as they developed through the years.

About this time, June 6th, 1886, a number of men from Eau Claire, Wisconsin, arrived in Calgary, Alberta, and started to build a saw mill, their first drive being in the spring of 1887. A small direct current generator had been installed by others in Calgary but it was not giving very adequate service. In Eau Claire, Wisconsin, since 1883, there had been two electrical companies operating and it was therefore logical that in 1889 an electrical generating plant was installed in the Calgary saw mill run by a Corless engine the steam coming from boilers run from saw mill waste. Before this plant was allowed to go into operation, there was considerable controversy between those interested in the old plant which was direct current and the new plant which was alternating current. Some time previously in the United States an alternating current generator had been presented to the Government and supplied the current that was used to electrocute criminals. The claim of the direct current exponents was that their power was absolutely safe, and people did not wish to use this undoubtedly dangerous alternating current, since it was used to electrocute criminals. This absurd statement is entirely untrue, although occasionally one still hears the myth. It is amusing to read of this same controversy developing in Calgary at about this time. However, those interested in the power plant in the saw mill were able to carry the day and primaries at 1000 volts were carried on the streets—50 volts being used on the secondary and in the residences. In 1893 a water power plant was installed and ran very successfully. An intensely interesting story of these early days in Calgary has been presented by Theodore Strom, first Engineer of the plant.

"I remember coming into the Eau Claire office one day when R. B. Bennett was there. He turned to me and said 'Your lights were pretty poor last night, Theodore, I could hardly find my bed.' The manager spoke up and said 'Theodore couldn't help it. We had an ice jam somewhere on the river last night and we were short of water.' Mr. Bennett said, 'Short of water, that's funny, the lights looked as though they had too much water in them.' "

In Mr. Strom's interesting reminiscences he tells of operating problems from high and low water, of difficulties with collecting consumers' accounts, of maintaining services, of repair of consumers' apparatus and diplomatic discussions with Government inspectors.

The public utility official of today would see many of the public relations problems shaping themselves in the early times. He would also realize that the necessity for a clear-cut policy was receiving serious consideration by the executives.

In the modern developments in Calgary and those of many cities and towns of the prairie provinces as well as developments in Central and South America, a Canadian, G. A. Gaherty, President of the Montreal Engineering Company and of the Canadian Electrical Association, has taken a leading part.

In 1881 the Ottawa Electric Company was formed to supply arc lamps in the city of Ottawa. Shortly after this a recent graduate in Engineering, John Murphy, was employed by Thomas Ahearn to operate this plant. It is interesting to quote from Mr. Murphy the following:—

"The electrical equipment consisted of three arc light dynamos with the capacity of the three of them totalling 16 horsepower. The three of them were driven by a little water wheel; two wires were run from each dynamo direct to the lamps and there were no service ammeters or voltmeters within ten miles of the plant. The entire system was controlled by hand and it rendered ideal service. If the lamps were not burning brightly, the water wheel gate was opened and the machinery speeded up a bit; if they were too bright, the operation was reversed. If it became necessary to work on a service while it was in operation, one of the brass binding screws on the dynamo was loosened with bare hands and the wire pulled out of the post. The arc was finally broken by pulling the wire further and further away."

Prior to assuming his duties in this plant in Ottawa, Mr. Murphy had operated a small generator in a saw mill and it is interesting to note the difference between the size of the generator installed at that time (two horse power) with the present Bryson plant of the Gatineau Power Company now on the same site.

In 1887 the Chaudier Electric Company supplied incandescent light to Ottawa, the voltage being 500 volts direct current with five lamps in series. In 1889 a change was made to alternating current. Later we find the same low water trouble that occurred in Calgary and in 1893 a steam standby was erected to take care of the variable flow of the river.

Back of this whole development of electrical power in Ottawa, as we have seen in Pembroke, was the man who was later the Hon. Thomas Ahearn, Privy Councillor. Thomas Ahearn was born of modest parentage in the city of Ottawa and was employed as a telegraph operator and early formed a partnership with A. Y. Soper. Their development carried them through the telegraph and telephone stage and through all of the early development of power in and around Ottawa district. In going over the development of power in Canada, time and time again one comes across the name of Thomas Ahearn, always searching out to the new and it was only fitting that he should be chosen as the chairman of the broadcasting committee of the Diamond Jubilee, 1927, who arranged the first Trans-Canada broadcast.

In 1894, these various companies in Ottawa were combined and we find as general superintendent a young man who had received his early education

in the city of Quebec and who had recently come to Ottawa as superintendent of the Chaudier Electrical Company. A. A. Dion from that time until his death a few years ago, gave of himself in developing an adequate electrical service for the city of Ottawa, in serving the Canadian Electrical Association and in giving wise council to the various engineering organizations in Canada. He was a leader who could be relied upon in any emergency. The development of the electrical utility in Ottawa, has kept abreast with the best engineering practice and is now under the care of a Canadian who has had experience in power development and utility management, not only in Canada but in Europe and South America, Major W. H. Munro, general manager of the Ottawa Electric Company and president of the Electrical Employers Association.

In a very similar way electrical utilities were being developed in the cities and towns of Canada. Montreal, Toronto, Winnipeg, etc., were being served, each from its local plant for the most part driven by steam power.

Sir Herbert Holt, a civil engineer with railroad experience, became interested in developing an adequate service for Montreal and shortly we see power plants installed at Lachine and at Chambly.

J. J. Wright, an Englishman, born in 1850, came to America in 1870, and at the Centennial Exhibition in 1876 met, and later worked with, Thomson and Houston, two science professors in a Philadelphia High School. In 1883 Mr. Wright came to Toronto and from then on, as far as electrical development in Toronto is concerned, his name loomed large.

Benjamin Franklin Reesor of Lindsay was responsible for many plants in towns such as Lindsay.

In this way, we find in the various cities and towns in Canada small systems being developed, the radius of their operations being very limited, owing to the necessity of using low voltages; first 52 volts and afterwards with the use of alternating current, being able to use a primary voltage of 2200.

(To be continued)

Research in Canada

By Lieut.-General A. G. L. McNaughton, C.B., C.M.G., D.S.O.

IT is to your precept and example in 1916, in the organisation of the Honorary Advisory Council for Scientific and Industrial Research, and the suggestion then made by the Government of the United Kingdom to our Government, that Canada should set up a similar body, that we trace the genesis of our own National Research Council. In the year 1916, we were in the earlier phases of the first World War and it had taken the impact of that event to shake the British peoples, both here and in the Dominions, from their complacency as regards research. Previously we had left research mostly to the universities, where its results as "pure science" were made available impartially to all, for the benefit of friend and foe alike. On the other hand, in industry, where mutual help would have been a great advantage, whatever each company was able to develop in the way of new apparatus, materials and processes was regarded as a trade secret, to be jealously kept to themselves, and particularly to be denied to other firms in similar business in their own country, though not necessarily to foreign associated companies.

Contrast this situation with that existing in Germany, where research—pure, applied, and industrial—had very early been recognised as a matter of profound concern, and where its organisation and correlation had been taken under the auspices of the Government itself. Under this meticulous care, every idea and invention was seized upon and subjected to intensive development at the hands of comprehensive groups of trained scientists; eager business men stood ready to exploit whatever they produced. There are many who will remember how this, and neglect on the part of other nations, had reacted to the great advantage of German world trade and so to the creation of a vast potential for munitions production in war. You know also of the great difficulties which faced the Allies on the outbreak of hostilities by reason of the German monopolies. The German dye industry, for example, which had taken the invention of a British chemist and turned it into a great commercial undertaking, led directly to efficiency in the production of explosives and of poison gas. I have often wondered why this menace was suffered to develop without adequate counter measures being taken, and it seems, on looking back, that its very gradualness must have been the answer, men's minds becoming accustomed to it by degrees.

Once started, British research in its relation to the war effort of the country developed rapidly and effectively, and at the end of the first World War it could be said with truth that one of the essential contributions to victory had been made by British and Dominion industry, once scientific and industrial research was organised and brought into play. To illustrate what was accomplished in Great Britain I mention a few significant facts. In 1914 there was no optical glass industry in the United Kingdom. Germany

Paper read before the Royal Society of Arts on April 13, 1941. Abridged.

and Austria had a practical monopoly in this field, and even the lenses of the sights of British guns were imported. Organisation of the scientists, followed by extensive basic and applied research, corrected this situation. To-day, the optical glass produced in Britain is of the finest quality in the world. I mentioned poison gas—chlorine—a product of the German chemical industry which was used against the French and the left flank of the First Canadian Division on April 22, 1915. The Germans used it against us thinking that the Allies would not be able to reply in kind (they were contemptuous of our scientific organisation), but by the summer of 1918, as a result of organised research, our chemical industries were producing mustard gas by a new process at a rate many times that which had been found possible by Germany.

The National Research Council and its Development up to 1939

As I have said, the organisation of research in Canada as a function of Government dates back to 1916, when we followed your example and set up an Honorary Advisory Council for Scientific and Industrial Research. It was not contemplated then that this Council would establish laboratories of its own; it was to act as an agency for consultation and co-ordination between those already carrying on research in the existing laboratories of the several departments of the Dominion and Provincial Governments, in the universities, and in industry. To give you some idea of the very limited facilities then available: a report prepared at the time indicates that the total annual expenditure on research in all Government laboratories, both Dominion and Provincial, amounted to considerably less than $100,000, and that of some 2,400 leading Canadian firms engaged in manufacturing which replied to the questionnaire sent out, only 37 possessed laboratories which even pretended to engage in research work.

Looking back at the history of the Honorary Advisory Council for Scientific and Industrial Research, in the war and early post-war periods, it is remarkable what was accomplished with the limited facilities at their disposal, but it is not to be wondered at that men who were informed on the subject should have realised the utter inadequacy of the provision which had been made and that they should have pressed for some improvement. As a result of the pressure of public opinion which developed, the matter was repeatedly considered in Parliament, and eventually the Research Council Act was passed in 1924, following in very close detail a draft which had been prepared by a non-party committee representative of both the Senate and the House of Commons. The Council's main laboratories, located at the junction of the Ottawa and Rideau rivers, were commenced in 1930 and opened at the time of the Imperial Economic Conference in 1932.

As was perhaps to be expected in the era following the Armistice of 1918, it was very difficult to obtain adequate funds for scientific and industrial research. While the need for co-ordination of this work as a wartime measure had been evident, recognition of the equally vital needs of competitive industry in peace-time came only very slowly until 1935, when the Government, despite the depression then rag-

ing, saw fit not only to double the current appropriation, but to provide substantial sums on capital account to complete the equipment of the laboratories. These increased appropriations were maintained by succeeding governments and steadily increased until, by 1939, the Council's annual budget on current account was somewhat over $1,000,000. Meanwhile, an even more striking increase had taken place in the facilities in Canadian industry itself, and by 1938 it is estimated that these comprised upwards of 1,000 industrial laboratories for research testing and plant control, with some 2,500 professional workers employed full time. Similarly, in the Dominion Departments of Agriculture, of Public Works, and of Mines and Resources the last two decades have seen the creation of a number of research and testing laboratories related to their special functions and duties, all of which represent a very substantial asset. Elsewhere the most notable addition was the Ontario Research Foundation, which operates in the most friendly relation with the National Research Council.

In 1938, provision for a further large group of laboratories, to provide the Council with additional facilities, particularly for aeronautical engineering, hydraulics, and high-voltage electrical engineering, was sanctioned by the Government. Construction was started in 1939, and is now advanced to the point that in some cases the buildings are in occupation. As a result of these measures, we had in Canada at the outbreak of the present war, in physical existence, the laboratories and trained staffs competent to act as a nucleus in undertaking the study of the problems presented in almost every field of war requirements, both within the sea, land and air forces themselves, and also in the industrial life of the country as it had to be re-oriented to produce the vast and complicated supplies needed in transition from peace to war basis.

I have been speaking of the actual research equipment of Canada, in the way of Government and industrial laboratories, as it stood at the outbreak of the war with a view to indicating the very favourable position in comparison with the situation on the previous occasion when we had to take up arms against Germany. But the adequacy of physical equipment and technical staff is only one side of the question, and what is probably equally important as an asset is the organisation of the Council itself as a going concern and the intimate relations which had been developed with every branch of science in Canada; with universities; with industry; with departments of the Dominion and Provincial Governments concerned with research problems; with the great professional societies in medicine, engineering, forestry, etc.; with the Canadian Engineering Standards Association in the field of industrial standardisation, and with many other organisations.

The National Research Council consists of fifteen members selected for terms of three years from among men prominent in scientific work in Canadian universities or in Canadian industry. The Council is required by statute to meet at least four times annually in Ottawa. There is a president, appointed by the Governor in Council for a term of years, who reports directly to the Privy Council Committee on Scientific and Industrial Research of which the Minister of Trade

and Commerce is the chairman. The office of president is now filled by Dean C. J. Mackenzie, M.C., of the University of Saskatchewan, an eminent civil engineer who served with the Canadian Forces in the last war. The Council's membership is broadly representative of all parts of Canada, and includes persons qualified to speak with authority in education, science, industry, business and finance. Apart from administration which is organised much on the usual lines of a department of Government, the staff of the Research Council is grouped in a number of divisions, each of which is under a director.

The divisions of physics and electrical engineering, chemistry, mechanical engineering, including hydraulics and aeronautics, biology and agriculture, are responsible for the direction and conduct of the technical work in the fields indicated by their designations. There is a section on research plans and publications concerned with the collection, collation and issue of scientific information and with the general development of co-operative investigations through committees, etc. There is also a section on codes and specifications, matters which are in the highest degree important in relation to mass production in war. Provision is made for the closest co-operation and collaboration between all branches concerned in any particular problem. One of the great advantages possessed by an organisation such as the Council's own laboratories, with their comprehensive representation of all branches of science, is that experts in every line required can be brought together at short notice to study a problem and to work as a team for its solution. This facility is very important, for in most research problems related to industrial or agricultural production or processing we are usually confronted with limiting factors of many kinds, and it is not easy to determine in advance in which branch of science the answer should be sought.

Associate Committees and Co-operative Research

Under the wide responsibilities placed upon the Council by Parliament, there is a duty to bring about the best possible use of all the country's facilities for research, of which the Council's own laboratories now represent only a small part. In order to bring to bear the knowledge of scientific men in other institutions and in industry and to correlate the work of research in all organisations concerned, a number of so-called "associate committees" have been set up. The function of these committees is to direct co-operative research on the problems assigned to them; to settle the objectives; to indicate the individuals or organisations which should undertake the several component parts of the inquiry; to receive and co-ordinate the resulting information, and to make it available to those who will turn it to advantage. The Council endeavours to ensure that these committees are comprehensively representative of all interests, and we expect them, each in their proper sphere, to form a national plan into which all who are in a position to contribute information can fit their own particular lines of research. The actual investigations are carried out, not only in the Council's laboratories, but in the laboratories of the various universities, Government departments and industrial institutions throughout the country. I cannot too

strongly stress the fact that much of the initiative in these committees lies with the outstanding experts from other organisations who have associated themselves with the National Research Council in this work.

Time does not permit me to recite to you the long list of these associate committees or to go into, in any detail, the important tasks which they are carrying out for Canada. But, in order to give some picture of the wide range of work involved, I should like, by way of illustration, to mention one or two in several diverse fields. In agriculture I would mention the committees in charge of grain research and of transport and storage of food—these, both by reason of the great importance of the subjects and also on account of the very substantial results which have been achieved in comparison with the trifling expenditures of money which have been made. In forestry, I would mention the committee, organised in co-operation with the forest service of the Department of Mines and Resources.

This Committee has concerned itself with such matters as the study of mitigation of forest hazards, through fire, insects and other pests, and the preparation of a manual giving advice as to the management of the "farmers' woodlot," a most important source of raw material. This manual is now in general use in the Maritime Provinces and Quebec. I could continue with examples of the work of many other associate committees in the fields of medicine, chemistry, physics and engineering; of the detailed and exacting work carried out by our joint committees with the Department of Finance in the preparation of a National Building Code for Canada, which is now, despite the war, in process of publication, and which should bring order into a situation which, under the conflicting jurisdictions of municipality, Province and Dominion had become most seriously confused to the disadvantage of the public. I could cite also the work on industrial codes and specifications carried out by the Canadian Engineering Standards Associations, which is a body intimately related to the National Research Council, and serves Canada as the counterpart of the British Standards Institution in this country.

Encouragement of Research in Universities, Etc.

In order to make use of the facilities for research which exist in a number of our Canadian universities and to encourage their further development, the Council, in the early years of its existence, instituted a system of assisted researches through which the professors in charge could be given financial assistance for the provision of needed apparatus, laboratory help and similar out-of-pocket expenses, other than their own salaries. Applications for such assistance are most sympathetically considered and by its aid much useful work has been accomplished, of value both for the new knowledge secured and, perhaps even more important, for the training given to the workers. Another aspect of the Council's concern with the training of research workers is represented by the scholarships which each year are awarded to some 70 or more post-graduate students. These are tenable at Canadian universities or, in special cases, abroad. Through these scholarships, which are being given year by year in increasing

numbers, in addition to providing the needed supply of highly trained research workers, a deliberate attempt has been made to assist the building up of the post-graduate schools in the Canadian universities.

From what I have said about associate committees, assisted research and scholarships, I hope I have made it clear that while the Council has itself a number of very well-equipped laboratories in all lines, yet there has been no attempt to monopolise research; in fact, the very opposite, for it has long been realised that for the safety of the nation against peace-time industrial competition, let alone to meet the needs in war, you can never have too much research. In Canada the difficulties are particularly acute for, as is well known, most of our principal industrial companies have affiliations with larger organisations abroad to whom there has been a natural tendency to refer any research problems that arise from time to time. It is often very difficult to examine these problems completely, apart from the special environment in which they have come to attention. The solutions proposed are often, therefore, inadequate, and, both on this ground and on account of delays, very heavy losses are involved. A more serious loss is due to the fact that without a corps of trained investigators on the spot, the needs of the situation are not fully appreciated, and many opportunities for useful inventions and developments are missed or unduly delayed.

Research Information and International Affiliations

In peace, in order to maintain our contact with research work going on all over the world, the Council maintains membership in the principal International Scientific Conferences and meetings, arranges for Canadian representation where required, and collects in its library in Ottawa, for reference, copies of all papers, proceedings and other information of importance. This is made available as desired to Canadian workers. For many years also the Council has maintained the closest possible contacts with the Department of Scientific and Industrial Research and the British Standards Institution here. These contacts were strengthened and developed by the Imperial Conference of 1930 and the Imperial Scientific Conference of 1936, and again in August, 1939, on the occasion of the visit to England of a representative group of Canadian manufacturers, who had come to England to familiarise themselves with the needs of war-time industry, so that Canadian production could be directed to those articles which would be most required and most useful.

War-Time Developments

I have endeavoured to give you a brief picture of the origin and growth of the National Research Council up to the outbreak of the war in which we are now engaged. Relatively satisfactory as the situation had become when compared with 1914, I have not claimed that we had in Canada anything which was in any sense an adequate answer to the problems of competitive industry in peace, and certainly, as regards war, we scarcely dare, in the years of the ascendency of the Geneva school of thought, to admit that some of the research work in hand might even have an indirect value for defence. Apart from meeting the problems of the day as they presented

themselves, what had been aimed at was the creation of a nucleus round which the research resources of the nation could be crystallised in order so soon as the real needs were recognised by public opinion and Parliamentary support was forthcoming. That such a nucleus was in fact created will, I think, be evident from what now I have to tell you with reference to the war-time developments of research in Canada. In this I am under the difficulty that no specific information which would be of value to the enemy can be disclosed, so I have to content myself with a few illustrative statements which must be rather general in character.

First, as regards finance. The funds placed at the disposal of the Council for the current year by votes from Parliament and grants-in-aid from the Naval, Land and Air Forces in the Department of National Defence are some five-fold greater than for the last pre-war year. In addition, the Council and its technical staff will be responsible for the scientific and technical organisation and advice in connection with other projects not directly administered, which will involve about twice to three times as much again. Further, in order to provide some measure of elasticity in the finances of the Council a number of Canadian corporations, large and small, and private individuals have joined together to establish a trust fund of well over a million dollars, with more available if required. The committee in charge has been enjoined by the donors to make it their business to ensure that no worthwhile project of research, related to the war effort of Canada, which is sponsored by the National Research Council, should be delayed or hampered by lack of money. In this public-spirited group the mining industries of Canada have, as usual, been conspicuous for their generous support of research. Another example of the assistance received from this source is the support given to the Canadian Corps in the organisation and equipment of our Tunnelling Companies. One of these, as is well known, is now at Gibraltar making effective use of the modern machinery presented by the Canadian mining industry. The other Company is using similar equipment in this country.

What is, in effect, a further additional expansion of the Council's activities is represented by Research Enterprises, Limited, a wholly owned Government corporation which has been set up by the Canadian Ministry of Supply primarily to produce for the armed Forces, and for industry, inventions and apparatus which had been developed in the Council's laboratories. Already, optical instruments, including gun sights and range finders, radio gear and similar articles, are in production in the large new factory which has been erected, and very shortly the company will be turning out its own supplies of optical glass in quantity. Thus a small nucleus established in the optical and radio laboratories in the years before the war has been given substance and developed into a key industry of essential importance for our war effort. The Council's metrology laboratories are another example of a small but effective nucleus which has been expanded to large dimensions to care for the standardisation of the vast number of gauges necessary in the munitions industry.

In the field of radiology, special attention has been paid in the Council's

laboratories for many years to the examination of castings, particularly those in light alloys required to carry stress in aircraft construction. Working with the producers, the technique of making sound castings had been developed before the war to a high degree of perfection, and the knowledge of this art is now proving of great value to the Canadian aircraft industry. X-ray photographs can be taken at up to 600 kv, which is sufficient to penetrate several inches of steel. For greater thicknesses a plentiful supply of radium is available by reason of the fact that the bulk of the world's new supply derived from the mines at Great Bear lake and refined by the Eldorado Company at their Port Hope plant comes to the Council for test and certification. Turning to another of many fields, I should like to mention the very important programme which has been initiated by the Committee on Aviation Medicine under the chairmanship of the late Sir Frederick Banting.

In conclusion, I wish to assure you that all this great range of work of which I have been speaking is going forward in Canada in the closest sympathy and understanding, both with the authorities here and also with our mutual friends and colleagues in the United States. In order to help in the maintenance of effective contact the British Government have established a Scientific Liaison Office with the Council in Ottawa, and we have been privileged to receive first, Professor Fowler, and more recently, Sir Lawrence Bragg. At the present time a number of the senior members of the Council are in England to familiarise themselves with the latest methods and requirements so that our work may be kept related to problems of immediate practical importance. There is a constant flow and interchange of workers and the various problems are taken up as available facilities best indicate. Needless to say, there is no delay or reservation in making the results available for application and use.—*Engineering.*

Barrett Chute development, Madawaska river. Power-house site in foreground, on shore of Calabogie lake.

New C.E.S.A. Electrical Standards

THE Canadian Engineering Standards Association has just issued the following three Approvals Specifications under Part II of the Canadian Electrical Code, the requirements of which must be met in order to obtain C.E.S.A. approval of the electrical devices concerned. These standards were prepared in collaboration with interested manufacturers and industrial associations, and are based on laboratory tests and record in service.

* * * *

C22.2 No. 0-1941—Definitions and General Requirements (Third Edition)

This Specification, as indicated by its title, covers definitions and general requirements to which reference is frequently made in other Specifications issued under Part II of the Canadian Electrical Code. All manufacturers of electrical equipment should therefore provide themselves with a copy of this new edition of the Specification.

This third edition has been published in loose-leaf form in order to facilitate the insertion of revised pages from time to time, as practice in the field and revisions to governing rules in Canadian Electrical Code, Part I, affect the requirements of this Specification. Various changes appear in this new edition, most of them having been made in order to bring it into agreement with the requirements of Part I of this Code. This Specification is effective as of July 31, 1941, for new production.

* * * *

C22.2 No. 28-1941 — All-Asbestos and Asbestos Varnished-Cambric Insulated Wires and Cables

This Specification applies to conductors having insulation of asbestos, or of varnished-cambric and asbestos, either of which may be provided with an outer covering of cotton, or asbestos braid, or a lead sheath. The wires and cables covered by this Specification, depending on the type of construction, are intended for use on supply circuits having maximum potentials of 300 or 600 volts. This Specification does not cover conductors composed of any material other than annealed copper; except that stove wire and appliance lead wire may have conductors of either annealed copper or nickel. This Specification is effective as of August 15, 1941, for new production.

* * * *

C22.2 No. 58-1941—Isolating Switches (For High-Potential "Disconnect" Use)

This Specification applies to air-break switches without enclosures, for use as isolating switches for potentials of from 751 to 15,000 volts inclusive for both indoor and outdoor use, a.c. or d.c. designed to be employed in accordance with the Rules of Part I of this Code. This Specification is effective as of September 1, 1941, for new production.

* * * *

Copies of these standards may be

obtained from the Canadian Engineering Standards Association, National Research Building, Ottawa, price 50 cents each, with the exception of Specification C22.2 No. 0 which is priced at 75 cents per copy for the standard paper-covered edition and $1.00 per copy for those bound in looseleaf "Wiro" binding with fabricoid covers.

A small stock of these Specifications is also carried by the C.E.S.A. Approvals Division at 8 Strachan Ave., Toronto, and at 325 Coristine Bldg., Montreal.

District No. 3 O.M.E.A. Meeting

THE first annual meeting of District No. 3, Ontario Municipal Electric Association, was held in Fort William on September 23rd and 24th, 1941, with fourteen delegates registered. A number of representatives for outlying points were unable to reach the Lakehead due to floods which disrupted railway and highway transportation.

Vice-President J. R. Pattison of Fort William welcomed the delegates and expressed the hope that the meeting would be the beginning of yearly conferences. He spoke of the importance of Hydro and the benefits the North Country had enjoyed under Hydro administration of power resources.

T. C. James, District Engineer of the Hydro-Electric Power Commission of Ontario, reviewed the growth of the Thunder Bay system and discussed its potential power resources at one of the sessions.

K. A. Christie, K.C., of Toronto, representing Dr. W. J. Chapman, President of the O.M.E.A., addressed the Tuesday noon luncheon and urged the fullest co-operation in all things affecting Hydro. Mr. Christie spoke briefly on the major issues now under discussion between the Association and the Hydro Commission, including the Hydro Pension and Insurance Plan, power reserves, and Unemployment Insurance.

On Tuesday evening a complimentary dinner was provided by the two Lakehead Commissions of Port Arthur and Fort William at which one hundred and fifty guests including delegates and representatives of civic bodies were present. Mayor C. M. Ross of Fort William and Mayor C. W. Cox of Port Arthur extended civic greetings and Hon. W. L. Houck, Vice-Chairman of the Hydro-Electric Power Commission of Ontario spoke on the part Hydro is playing in our war effort and gave interesting facts regarding the Thunder Bay system. J. R. Pattison presided at the dinner.

The meeting included an inspection trip on Wednesday, September 24th, to the Nipigon river where the generating plants at Cameron Falls and Alexander were visited.

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Utilization of Hydro-Electric Power by the Mining Industry in Northern Ontario

Supplied by the Hydro-Electric Power Commission of Ontario

By T. C. James, Assistant Engineer, H.E.P.C. of Ontario

THE enormous expansion of the mining industry in Canada, and particularly in Northern Ontario, has been contingent upon the availability of an adequate supply of cheap hydro-electric power. In the province of Ontario where energy is required in large quantities for carrying on mining operations, any other means of electric power generation is an economic impossibility. The use of diesel-engine power has been tried, but the high load factor operation of producing mines, particularly in the gold field, requires approximately double the amount of power generating equipment ordinarily necessary with that source of supply. The problem of transporting coal over great distances, with a resultant high haulage cost also makes steam-driven generating units economically out of the question as a source of power for this class of load, especially when operations have reached the production stage. The absence of coal in Canada's geological structure, except in the extreme eastern and western portions of the country, therefore, excludes steam-driven units as a source of power generation with which to develop and market the heritage in mineral wealth with which we have been so richly endowed.

In what is known as the Pre-Cambrian Shield, in which area is located Canada's great mineral wealth, water courses and water falls exist in great abundance. Nature has, therefore, provided a potential source of power in that area, which makes it possible by

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NOVEMBER, 1941

The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

the application of advanced engineering practice, to secure all of the power necessary with which this mineral wealth can be developed and produced ready for shipment to the world's markets.

In 1909, when through the foresight and untiring activities of the late Sir Adam Beck, the distribution of hydro-electric power throughout the province of Ontario was inaugurated by means of government assistance and municipal co-operation, mining activities in Northern Ontario were in their extreme infancy. The first two decades of Hydro expansion were confined to power supply in the more thickly settled and industrial areas in the southern and eastern portions of the province. By the year 1929, however, mining operations in Northern Ontario were rapidly expanding into a major industry, and power supply was becoming an acute problem, especially at rates which would assist existing producing mines, and encourage the development of prospects. The third decade of Hydro activities throughout the province belongs to Northern Ontario, in spite of the fact that great expansions were still continuing in the well established southern and eastern districts. The Hydro-Electric Power Commission entered the Northern Ontario field in 1929, specifically to assist the mining industry. In proportion to the number of customers served, the expansion in load growth and territory covered has been phenomenal, and perhaps the greatest in Hydro history to date. During the first two decades of Hydro operation in the southern and eastern portions of the province, the art of electrical engineering practice rapidly advanced, particularly in the transmission and industrial application fields, and when activities began on a large scale in Northern Ontario, the experience which had been gained in both design and utilization of electrical equipment made it possible for the Commission to keep pace with the exceptionally heavy demands for service.

In the southern and eastern areas of the province the distribution of elec-

Ear Falls power development.

trical energy has been made possible by municipal corporations guaranteeing the capital investments and commitments of the Commission on their behalf, thereby securing their supply of power on a cost basis. This scheme was unworkable in Northern Ontario, due to the populated areas being scattered and isolated, with the bulk of the power supply being dependent more or less upon mining operations only. Furthermore, as the life of a mine is limited to the extent of its ore reserves, there was no definite indication as to the length of time that any given transmission line or transformer station might remain in service. It was finally determined, therefore, that the Provincial Government should sponsor outright all investment in plant and equipment for the generation, transmission and distribution of electric power in the mining districts, and that The Hydro-Electric Power Commission of Ontario should design, construct and operate all works as trustee directly on behalf of the Government. This scheme is being carried out in all Northern Ontario areas, excepting the Thunder Bay system, which still operates on a cost basis, and the various systems so operated have been designated—the "Northern Ontario Properties".

In the fall of 1928 the officials of the Howey gold mine approached The Hydro-Electric Power Commission regarding power supply to their property in the Red Lake district. These negotiations were completed by the execution of a contract in 1929 which resulted in the Commission undertaking the construction of a power development at Ear Falls at the foot of Lac Seul on the English river. The first installation at this location consisted of one 5,000 h.p. unit. This was the beginning of Hydro operations in the north country, a beginning which made possible the opening up of a fertile field for gold mining purposes. When the development at Ear Falls was placed in operation in February 1930, and power first delivered to the Howey mine, mining operations in the Red Lake area ceased to be a probability and became a reality. The Howey mine was the first producing gold mine in north-western Ontario, and in the twelve years following the initial opening up of that property, ten additional mines have been prospected, explored,

developed and placed under production in the Red Lake and Pickle Lake areas alone. To supply the power demands of these mines it has been necessary for the Commission to enlarge on two different occasions the initial installation at Ear Falls to its present installed capacity of 17,500 h.p. It has also been necessary to construct an additional development at Rat Rapids on the Albany river at the foot of lake Joseph, of approximately 3,000 h.p. capacity. The initial installation was one 1,400 h.p. hydro-electric unit, first placed in operation on May 14, 1935. This development was enlarged in 1936 by the addition of a second unit of 1,750 h.p. capacity. The initial Howey load was 542 h.p., whereas the total mining load sold at the present time from the Ear Falls and Rat Rapids developments approximates 14,000 h.p. The operating mines in the Red Lake and Pickle Lake areas of Patricia district supplied with hydro-electric power at the present time are—Central Patricia, Cochenour Willans, Hasaga, Howey, Jason, Madsen Red Lake, McMarmac, McKenzie Red Lake, Pickle Crow and Uchi. Service in this area is supplied at transmission voltage at a frequency of sixty cycles.

After closing the power contract with Howey, which enabled the Commission to proceed with the construction of Ear Falls power development, events moved rapidly in respect to power supply for mining projects in all sections of the Northern Ontario area. In April 1929, the Commission acquired control of the assets of the Wahnapitae Power Company by a majority stock purchase, thereby obtaining the use of three hydro-electric developments on the Wanapitei river in the district of Sudbury, having at that time an installed capacity of 15,700 h.p. This purchase included the contracts for power supply to the Mond Nickel Co. (now the International Nickel Co.) at Coniston, amounting to approximately 4,000 h.p., and 500 h.p. supplied to the Falconbridge Nickel Co. Since that date the Commission has purchased the Crystal Falls development on the Sturgeon river from the Abitibi Power & Paper Co., having an installed capacity of 10,000 h.p. No growth change has occurred in the original Mond Nickel Co's. load at Coniston, but the Falconbridge Nickel Co. has greatly expanded, and is now taking approximately 8,400 h.p., to be substantially increased by the spring of 1942. A portion of this Falconbridge load is supplied at 25 cycles from the Abitibi Canyon development due to capacity limitations of the Wahnapitae and Crystal Falls developments, which operate at sixty cycles. Service to mining customers in the Sudbury district from the 60-cycle supply is given at a transmission voltage of 22 kv. Power is also supplied to the city of Sudbury and the adjacent rural districts. When the Wahnapitae plants were acquired in 1929 the 60-cycle mining load supplied from same was approximately 4,500 h.p., whereas at the present time, approximately 9,000 h.p. is being supplied for that purpose in the Sudbury district from the four hydro-electric developments supplying that area.

In April 1930 the Commission closed a contract with the Ontario Power Service Corporation, a subsidiary of the Abitibi Power & Paper Co. for the

Cameron Falls power development.

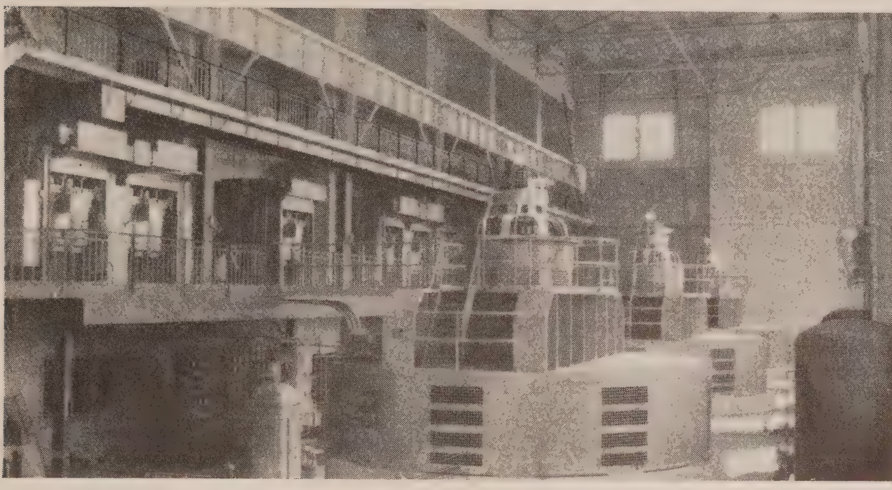
purchase of 100,000 h.p. from that Company's Abitibi Canyon development, then under construction. The purpose of this deal was to provide for the power demands of The International Nickel Co. at Copper Cliff, and the gold mines in the Porcupine, Kirkland Lake, Matachewan and Larder Lake districts. The International Nickel Co. signed its power contract with the Commission in April 1930 for the taking of 16,000 h.p., under which delivery is made at approximately 110 kv., 25-cycles, over a double circuit steel tower transmission line, constructed at the time the agreement was signed by the Commission, from Hunta to Copper Cliff. When the Courts placed the assets and operations of the Abitibi Power & Paper Co. in Receivership, the Commission acquired by purchase the unfinished Abitibi Canyon development, and undertook its completion immediately. The first unit was placed in operation under Commission management in May 1933. The total installed capacity of this development is 300,000 h.p. The first customer supplied with power by the Commission from this development was The International Nickel Co. at Copper Cliff, under its power agreement previously mentioned. The International Nickel Co's. load has expanded from an initial 16,000 h.p. to approximately 75,000 h.p. at the present time. From this beginning extensions and expansions have rapidly progressed throughout the Porcupine, Kirkland Lake, and adjoining districts, until at the present time over a period of nine years the available output of the Abitibi Canyon development has been completely contracted for and the Commission is now

studying other sources of power supply for these districts.

The second major contract for power supply from the Abitibi Canyon development was executed between the Commission and Canada Northern Power Corporation in November 1933, and power was first delivered to that company at Kirkland Lake in February 1934. The contract covered all growth power of the customer, which was used principally for mine operation for a period of ten years. The initial load approximated 5,600 h.p. whereas the maximum amount of power supplied to date under this contract exceeds 56,000 h.p.

The first contract executed by the Commission for power supply for mining purposes in the Porcupine district was with the Central Porcupine mine. This mine is not in active operation at the present time. Power was first delivered to this company in April 1935, the initial load being 263 h.p. At the present time thirteen mining properties are being supplied with power in the Porcupine area, the total load exceeding 22,000 h.p. The mines supplied by the Commission with power in the Porcupine area at the present time are —Aunor, Bonetal, Broulan, Buffalo Ankerite, Delnite, De Santis, Faymar, Hallnor, Hoyle, Moneta, Pamour, Paymaster and Preston East Dome. The first mining property supplied by the Commission in the Kirkland Lake district was the Bidgood Kirkland, power having been delivered to this mine for the first time in September 1934. The Matachewan area was first supplied with power in 1934, the first mine served being the Matachewan Consolidated in June of that year. In the Ramore area only the Hollinger's Ross mine in Hislop township is being served at the present time. The first mine served in the Larder Lake district was the Omega property in 1935, with an initial load of 216 h.p. The mining activities in the Shining Tree area are of comparatively recent origin. The first property served by the Commission in that district was the Ronda mine in 1938, which has since ceased to operate. At the present time two properties are being served, viz: Tyranite and Jerome. In these five districts at the present time thirteen mining properties are being supplied with power by the Commission, having a combined load approximating 29,000 h.p. These properties are Bidgood Kirkland, Golden Gate, Lakeshore, Lakeside Kirkland, Matachewan Consolidated, Young-Davidson, Chesterville Larder Lake, Kerr-Addison, Omega, Jerome, Tyranite, the Ross mine operated by Hollinger, and Yama.

The Northern Empire Mining Company signed a contract with the Commission in May 1933 covering power supply to its property located near Beardmore, approximately forty miles east of lake Nipigon in the Thunder Bay district. Power was first delivered to this customer in September of the same year, from the Cameron Falls development on the Nipigon river, the initial load being 247 h.p. This line was extended in 1934 to the Little Long Lac mine and power was delivered to that property in September of that year. Up to September of 1941 power was supplied by the Commission to ten mining properties in the Beardmore-Little Long Lac districts, the combined load sold to which approxi-



Interior of a generating station serving Northern Ontario mines.

mates 12,000 h.p. Service in this area is supplied at 60 cycles, 44 kv. The mines served are—Bankfield, Hard Rock, Leitch, Little Long Lac, Magnet Consolidated, MacLeod - Cockshutt, Northern Empire (closed down September 1, 1941), Sand River, Sturgeon River and Tombill.

With the construction of the Ear Falls development, and the purchase of the Wahnapitae Power Company's properties in 1929, followed by the completion of the Abitibi Canyon development, and the delivery of power to the Northern Empire mine from the existing Nipigon developments in 1933, together with the construction of trunk transmission lines originating from these power sources, the Commission had established and made available a dependable supply of power to all of the mining areas throughout the northern portions of the province. In the years following, down to the present date, it has only been necessary to enlarge existing power developments, and construct additional transmission lines and transformer stations to supply the power requirements of the mining industry whenever and wherever demands were created. This task, however, has been no easy problem during the twelve years of the Commission's activities in Northern Ontario, due to the steady increase in the demands established by the mining industry, and the rapidity by which prospect properties were developed and placed in production. In the Patricia district it has been necessary to enlarge the Ear Falls and Rat Rapids developments to a combined installed capacity of 20,650 h.p., and to construct a large terminal transformer station together with two hundred and fifty-nine miles of 44 kv. and twenty-seven miles of 22 kv. transmission lines; in the Thunder Bay district two transformer stations with capacities of 4,500 kv-a. and 9,000 kv-a., as well as ninety-three miles of 110 kv., and one hundred and sixteen miles of 44 kv. transmission lines have been constructed; in the Sudbury district the Crystal Falls development of 10,000 h.p. installed

capacity has been purchased and placed in operation, together with forty-six miles of 110 kv. connecting transmission line; in the Abitibi district eight large terminal transformer stations have been constructed and placed in operation, one having a capacity of 57,000 kv-a., one a capacity of 15,000 kv-a., two with capacities of 9,000 kv-a. each and four with a capacity of 4,500 kv-a. each; to supply these stations trunk transmission lines operating at approximately 110 kv. have been constructed and placed in operation to the extent of four circuits for a distance of 57 miles; two circuits for a distance of 282 miles; and one circuit for a distance of 77 miles, together with 33 miles of 26 kv. and 12 miles of 13.2 kv. single-circuit distributing lines originating at the various transformer stations and terminating at the customer's premises. All told, the Commission is now utilizing in Northern Ontario nine hydro-electric generating plants having a combined installed capacity of 475,000 h.p., and a dependable capacity of approximately 320,000 h.p., about 60 per cent. of which is being taken up by the mining industry. The difference between installed and dependable capacities represents the limitations caused by restricted output at low steam flow periods, as affected by seasonal flow variation, storage facilities, the load factor of the various customers supplied, and spare equipment. The total number of mining properties served by the Commission in Northern Ontario up to September 1, 1941 was sixty-two, of which twelve have ceased to operate, making a total of fifty now served. The total load sold to operate these various mines approximates 208,000 horsepower. Taking the total load sold to mines at the close of 1933, at which time the Commission had made its power facilities available and was delivering power in all four of the areas in which mining operations are active in Northern Ontario, namely: Patricia, Thunder Bay, Sudbury and Abitibi districts, as 27,000 h.p. and the total load sold in August 1941 for mining purposes as 208,000 h.p., the increase in this eight-year period has been 670 per cent.

The Commission's Annual Report at the close of its fiscal year October 31, 1930, during which period the capital invested in the Ear Falls development in the Patricia district, and in the Wahnapitae developments in the Sudbury district definitely became active under the heading of Northern Ontario Properties, gives the total investment in plant utilized mostly for power supply to mining properties as approximately $3,300,000. Ten years later, as at October 31, 1940 the Commission's annual report showed a capital investment in plant utilized for similar purposes, of approximately $40,000,000. This comparison illustrates briefly, but most emphatically the extent of the effort which has been made by The Hydro-Electric Power Commission in meeting its obligations to the mining industry.

Although about two-thirds of the total hydro-electric power generated in Northern Ontario by The Hydro-Electric Power Commission is being utilized by the mining industry, the demands for municipal purposes and of the pulp and paper industry represent a considerable amount, especially in the Thunder Bay district at Port Arthur and Fort William, also at Sud-

A four circuit, 110 kv. steel tower line serving mining areas.

bury, and this class of load will account for about one-third of the total load generated. At the present time the dependable capacity of the various hydro-electric generating plants of the Commission in this area has practically all been utilized in supplying the power demands of mines and other customers and it will be necessary in the very near future to provide additional generating plant capacity, either by the installation of additional equipment at developments where such is permissable, or, by constructing power developments at new sites. For this purpose, the Ear Falls development can be increased by the installation of one additional unit of 7,500 h.p., before the ultimate installed capacity at that site is reached. Further development of other sites on the English river in Ontario is possible. There are nine falls on this river between the Ear Falls development and the Manitoba boundary, from which approximately 100,000 h.p. is obtainable. Additional power is obtainable at new sites on the Nipigon river in the Thunder Bay District to the extent of about 70,000 h.p. continuous power under present flow conditions. By means of the Ogoki diversion, now under construction, and expected to be placed in operation early in 1943, additional power can be obtained at both new and existing sites. This scheme provides for directing the flow of the upper portion of the Ogoki river through a diversion channel into lake Nipigon, thereby supplementing the flow of the Nipigon river which drains the entire Nipigon water shed into lake Superior. This additional flow will increase the power capacity of the Nipigon river by about 90,000 h.p. continuous power inclusive of existing and future developments. Further power development on the Nipigon river, therefore, is possible to the extent of approximately 160,000 h.p. In the Sudbury district it is possible to de-

velop the French river which drains lake Nipissing into Georgian bay to the extent of approximately 20,000 to 25,000 h.p. For the Abitibi district additional power can be developed on the Abitibi river above the Abitibi Canyon development, and at various sites on the Upper Ottawa, one-half of the capacities of which are available for Ontario, and may be utilized as a power source for supplying the demands of the area lying between James bay, Georgian bay, and the Quebec boundary. The Commission's engineers have been studying these various sources of future power development for some time past, and additional capacity will be made available from either one or all of these sources, when required. To provide for the requirements during the construction of additional developments at new sites, it is possible for the Commission to purchase power from two existing sources from which approximately 35,000 h.p. might be obtained, thus assuring the mining industry a sufficient supply of power, to meet any further expansion which may develop, without the danger of a power shortage.

Sanitation

A Brief Sketch of its Growth and Importance

By J. Albert Smith, Commissioner, H.E.P.C. of Ontario

SANITARY engineering has a long and interesting history. Whenever members of the human race have gathered into communities the problem of the disposal of wastes has engaged the attention of those responsible for the government of the communities.

We are all familiar with the Roman roads which contributed so much to the extension of the Roman Empire, and we have all seen pictures of the great aqueducts, which are milestones of our civilization, but it is not so well known that sanitation was from an early date a feature of Roman life. You gentlemen are probably aware that the main drain of Rome dates back to the period of the Tarquins in the sixth century B.C., when Rome was already provided with subterranean sewers. Notwithstanding these facts and the knowledge that was available from the civilizations of Greece and Rome, many long centuries elapsed before the sanitary disposal of wastes was generally recognized as essential to the safe growth of cities.

The growth of sanitary engineering was early linked with the practice of preventive medicine. While the medical profession was groping for more exact knowledge, there was an empirical movement of practical prevention taking place. The men who built and governed cities had long sought to stem the tides of disease which threatened to overwhelm them. Even in Britain it was the ravages of pestilence in the middle ages—of leprosy in the 12th century—of the black death in the 14th—of sweating sickness in the 16th—

Address to Annual Convention of The Canadian Institute on Sewage and Sanitation at Kitchener, Friday, October 17th, 1941.

and of cholera and smallpox later on,—which compelled attention to the conditions which seemed responsible for these scourges.

In 1388 was passed the first sanitary act in England, directed to the removal of nuisances. Under Queen Elizabeth scavenging became more stringent, and as time passed men began to see that environment was one of the principal factors in the origin and spread of diseases. Progress, however, was slow, very very slow, to our modern way of thinking. In 1843 a royal commission was appointed by Sir Robert Peel, at the instigation of Edwin Chadwick, to enquire into the outbreak of disease in large towns and the best means of improving the public health. This led to the passing of a comprehensive sanitary measure in 1848, the establishment of a General Board of Health and the appointment of medical officers of health. In 1869 was appointed the Royal Sanitary Commission, which recommended that "the present fragmentary and confused sanitary legislation should be consolidated". They proposed a Minister of Health, but the case miscarried. However, the Local Government Board was created in 1871. The Royal Sanitary Commission's summary of the national minimum of "What is necessary for civilized social life" had ten clauses. The third was, the provision of sewerage and utilization of sewage; the sixth the removal of nuisances and refuse, and consumption of smoke.

As we glance back over the long history of the human race we sometimes become impatient at what appears to be the slow progress made in finding remedies for conditions obviously inimical to the health and welfare of the people. But have we a right to be critical? The rapid growth of the United States was associated with very primitive sanitary conditions so that epidemics of typhoid fever and other preventable plagues marred the development of the country. In many instances water supplies were contaminated, and sewage and wastes were disposed of in ways that were unsanitary and unsatisfactory. Similar conditions obtained in Canada. Even today we have to admit to our shame that primitive sanitary conditions still obtain in many sizable communities and to a far greater extent than should be in rural districts of Ontario.

Fortunately we have now a valuable tool to enable us to remedy these conditions. I refer of course to the growth and extension of Hydro service, not only to the cities and towns, but to the rural villages and hamlets and to the individual farms. Wherever Hydro service is available, the farmer can provide sanitary conditions equal to the best the city affords. As the means of ensuring sanitary conditions throughout the length and breadth of our fair Province are provided, we must not be timid in putting into force those measures which will make it obligatory and economically possible for small communities and individual farms to have running water and modern plumbing with satisfactory disposal facilities.

As has happened so many times in the past, war has temporarily slowed up the provision of these necessary reforms. Fortunately during the past ten years the Commission has been able to extend rural service to about 80 per cent. of those rural inhabitants

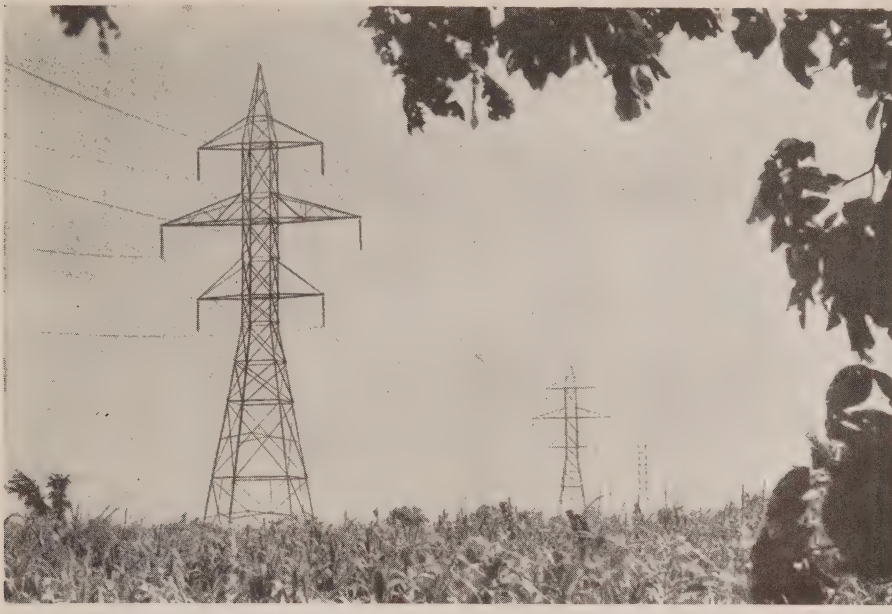
who are within economical transmission distance of supplies of Hydro power. For the moment, due to the fact that all available supplies of power must be devoted to the war effort of Canada and to the difficulty of obtaining the necessary material for the extension of transmission lines, it has been necessary to call a halt to further extensions in the rural districts.

I notice from your programme that you have been discussing many interesting detailed sanitary problems. In my contact with engineers I am constantly being impressed with the thoroughness engendered by a scientific approach to the details of the various problems dealt with. This seems to be as true in sanitary engineering as in the electrical supply business. This meticulous attention to detail has led to an immense improvement in the status of the engineer.

In Edward Bellamy's "Looking Backward"—which some of you will no doubt recall as a delightful Utopian picture of things to come in the year 2,000—those who do the unpleasant tasks receive the same reward for their labour as those whose inherent ability enables them to undertake more responsible duties. William Morris in his "News from Nowhere", which purports to describe London, England in the 21st century under a socialist state, introduces a character by the name of Boffin who is described as "a splendid figure . . . a man whose surcoat was embroidered most copiously as well as elegantly, so that the sun flashed back from him as if he had been clad in golden armour". The visitor from London of the present day, concluded that this resplendent individual must be at least a Senator but upon enquiry found that he performed an unpleasant but necessary civic duty—that of garbage collection.

I have not noticed that the men responsible for the disposal of our municipal domestic and industrial wastes have yet adopted the gay costume of the troubadour, nor, I surmise, does the pay they receive for their varied responsible duties entirely meet their wishes, but I think you will agree that the past fifty years has seen an immense improvement in the methods for the disposal of such wastes and also an improvement in the status of the sanitary engineer.

The interchange of knowledge and experience promoted by these conventions and discussions contribute very largely, both to the effectiveness of your service to the public, and to the status of your honourable calling. It is sometimes pointed out that the mistakes of the architect and the professional engineer are apt to become monuments, whereas the mistakes of the medical profession are frequently placed underground. In the case of the sanitary engineer a large proportion of his successful work is placed underground, or in some out-of-the-way district where it will not attract public attention. Its importance however can hardly be over-estimated, and I trust that satisfactory reports of your convention will further enlighten the public as to the important part played by the sanitary engineer in the welfare of modern cities.



The New 220,000 Volt Double-Circuit Transmission Line in Toronto-Hamilton Area 1941

OCTOBER 1st, 1928, marked the inception of the 220,000 volt transmission of electric power in Ontario to the metropolitan Toronto area. An account of the subsequent expansion of the 220,000 volt system has been given in an article in *The Bulletin* for July, 1941. The new Burlington station was placed in service on August 24th, 1941, and the second 220,000 volt line connecting to it on October 26th, 1941. This second line is one of the circuits on the double-circuit towers.

The general details of the design and loading on these towers are covered in the article mentioned above in the July *Bulletin.*

The construction work on this line was done by the Commission's Construction Department, in the manner described in the following paragraphs.

After the line had been located and surveyed by the Engineering Department, profiles showing the type and location of each tower together with bills of material required were supplied the Construction Department, which issued shipping instructions covering towers, conductor, ground cable clamps, and other materials.

Practically all of the grillages were set, as a test of a new method, by the sub-foreman, using a transit and tape, setting one corner at a time, thus eliminating the inconvenience of transporting of templates. Four stakes were set on the diagonals of the tower at a

Standard 220,000 volt double-circuit tower (1941).

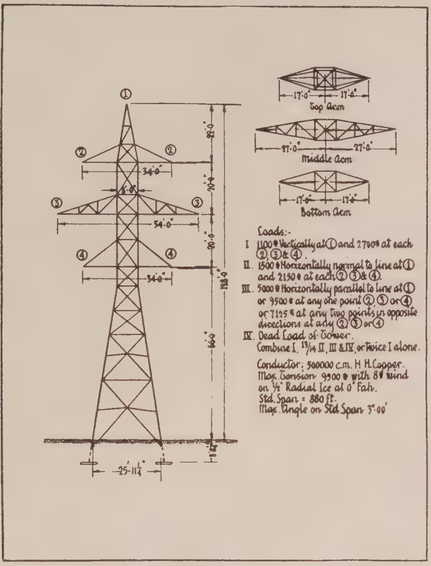
certain known distance from the centre stake and outside the footing stubs. After the excavations were dug the grillage and stub were lowered into the hole and lined up in the proper position. For the top of the stub, a tape only is necessary, using the centre stake and the stake on the diagonal

Double-circuit transposition tower at Yonge Street (1941).

to line in the stub. For the bottom of the stub a plumb bob is necessary. When the grillage is in its proper position, it is braced against the side of the excavation so as to prevent movement of the stub during back-filling.

On all semi-anchor towers and on suspension towers carrying a 2° angle or greater, the excavations were undercut approximately 6 inches and a concrete slab poured around the footing channels and cross ties. If the distance the concrete slab projected beyond the grillage was greater than the depth, the slab was reinforced with scrap steel or rods.

After the grillages were set, the tower gangs followed along. In erecting the towers, the steel was assembled in

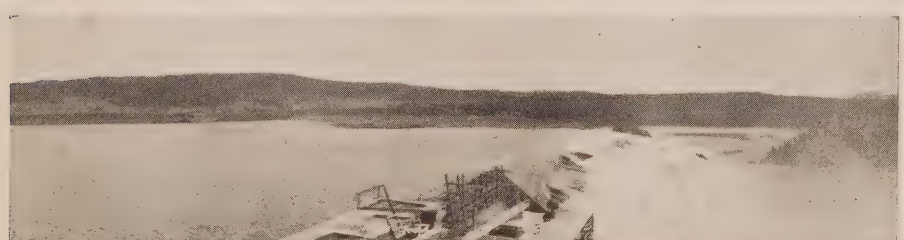


Clearance and loading diagram for standard tower.

panels and hoisted into place using a gin pole inside the tower. For the first panel the gin pole rested on the ground and the top guyed in four directions. As the tower was built, the gin pole was hoisted and supported at the bottom by four slings attached to the tower legs at the panel points. The four guys at the top permitted tilting the gin pole to any side as required. Assembling the panels on the ground speeded up erection and also permitted tightening a considerable number of bolts on the ground where it could be done more economically.

Cable stringing was done by another gang which followed the steel erection gang. Each tower was equipped with travellers at the lower end of the insulator strings and at the ground cable support. In unreeling the cables, as each tower was passed a rope was run through the traveller and the ground cable or conductor drawn through the traveller by means of a mesh type cable grip attached to the rope. Due to the weight of the copper cable on this line, only one conductor or the ground cable was strung out at one time. After the cable had been sagged in, i.e. pulled until the sag is correct, a suspension clamp was substituted for the traveller and the cable clamped in. Since there is a certain amount of friction in the travellers it was necessary to "sag in" this heavy conductor every mile beginning at the far end and working toward the end at which the cable was being pulled. The ground cable was "sagged in" and "clamped" at the same time.

Before turning the line over to the Operating Department, the Forestry Department made a check survey on the clearances to trees along the right-of-way. A "clean-up" gang took care of any additional trimming shown to be necessary and at the same time tightened any loose bolts, added more backfill where necessary, and generally took care of any small details which may have been overlooked earlier.—*C.A.S.*



Some Practical Electrical Tests For Transformers

Determining Three Phase Losses of Core Type Transformers by Single Phase Methods

By F. K. Dalton, Testing Engineer, H.E.P.C. of Ontario

IN the November 1936 issue of *The Bulletin*, under the above title, the writer described some unusual tests for power and distribution transformers by means of which special information had been obtained as to their characteristics which was not available from standard tests. Many of these methods have now been used by transformer manufacturers and, in several instances, have been adopted by them to procure design information.

The method of determining three phase losses by single phase measurements was then described for star connection only. A similar method has since been applied for delta connection. Both of these have been used in many cases not only for obtaining three phase values but also for analyzing conditions where trouble has been found. Recently, a "Zig-zag" grounding reactor was tested in this manner.

Determination by single phase measurements is particularly of advantage (a) where the test department is not equipped with a three phase supply of voltage, (b) where there is such a supply but voltage is not well balanced, or (c) where high voltage is to be used and there are not sufficient instrument transformers available so that it would become necessary to change connections during the tests. These methods also provide an excellent check on three phase measurements when there is considerable variation in voltage.

THREE PHASE STAR CONNECTION

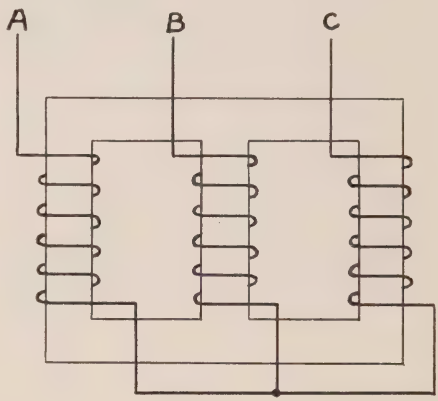


Fig. 1.

Where the winding to which voltage is to be applied for core loss or copper loss measurements is connected in star, the other winding, not shown in the diagram, may be in either star or delta.

Core Loss and Exciting Current

Single phase voltage is applied first between terminals A and B, Fig. 1, and adjusted to a value equal to twice the normal voltage per leg of this winding; readings of core loss and existing current are taken. Terminal C is open during this test.

The same value of voltage is next applied between terminals A a C, with terminal B open, and readings taken. It is then applied between terminals

B and C, with terminal A open. It will be observed that the readings taken on terminals A and C are higher than readings on the other connections, which should be equal to each other. With terminals A and C, two legs and four yoke sections are involved, whereas with terminals A and B, or B and C, two legs but only two yokes are included. In each case the sections magnetized are at normal flux density.

It will be observed that if these three core loss measurements be added, each part of the core is included twice. Half the sum of the three readings, therefore, is the normal three phase core loss of the transformer.

Core Loss (3 phase) =

$$\frac{W_{AB} + W_{AC} + W_{BC}}{2}$$

The three readings of exciting current are added and averaged; the result is a close approximation of the average three phase star exciting current on balanced normal voltage.—

Exciting Current (3 phase) =

$$\frac{I_{AB} + I_{AC} + I_{BC}}{3}$$

Copper Loss and Impedance

Where copper loss is to be measured and voltage is to be applied to a star-connected winding, the other winding, whether star or delta, is short-circuited in the usual manner including all terminals. Voltage is then applied to terminals A and B, with terminal C open, and adjusted to give normal full load current in these two phases. Readings of voltage and copper loss are then taken. Following this, similar readings are taken at normal load current on terminals A and C, then on B and C, the third terminals being open in each case.

The three copper loss measurements are added. Half of this sum will be the normal three phase copper loss of the transformer. The three impedance voltage readings are also added, averaged, and the result multiplied by $\frac{\sqrt{3}}{2}$ to give the normal three phase star impedance voltage.

Copper Loss (3 phase) =

$$\frac{W_{AB} + W_{AC} + W_{BC}}{2}$$

Impedance Voltage (3 phase) =

$$\frac{V_{AB} + V_{AC} + V_{BC}}{3} \times \frac{\sqrt{3}}{2}$$

THREE PHASE DELTA CONNECTION

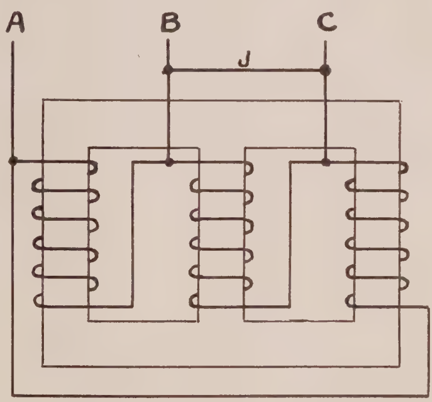


Fig. 2.

When the winding to which voltage is to be applied for measurement is connected in delta, the principle is the same as before but the method differs slightly. However, in this case also, the other winding, not shown in the diagram, may be in either star or delta connection.

Core Loss and Exciting Current

Single phase voltage, at normal delta phase value, is applied to terminals A

and B, with a jumper, J, connecting B to C, as shown in Fig. 2, which short circuits the windings on the centre leg of the core. Readings of core loss and exciting current are taken. Voltage is applied again to the same terminals but with A and C connected together by the jumper, and similar readings are taken. For the third set of measurements, voltage is applied to terminals A and C, with the jumper connecting A to B. The three sets of readings, therefore, are taken under conditions where the three leg windings are short circuited separately and respectively. Where the winding of one leg is thus short circuited, no appreciable flux will flow through that leg of the core. The flux, therefore, will be confined to definitely known legs and yokes, just as with the star connection. The readings with the jumper short circuiting the centre leg will be the highest of all. The other two readings should be equal to each other.

The three phase core loss will be half the sum of the three readings as before.

Core Loss (3 phase) =

$$\frac{W_{J\text{-}BC} + W_{J\text{-}AC} + W_{J\text{-}AB}}{2}$$

($W_{J\text{-}BC}$: with jumper from B to C)

In each connection, two legs are being excited in parallel. The normal three phase delta exciting current, per line, then will be the average of the three readings multiplied by $\frac{\sqrt{3}}{2}$.

Exciting Current (3 phase) =

$$\frac{I_{J\text{-}BC} + I_{J\text{-}AC} + I_{J\text{-}AB}}{3} \times \frac{\sqrt{3}}{2}$$

Copper Loss and Impedance

When copper loss is being measured with voltage applied to a delta-connected winding, the other winding is short circuited, including all terminals. With the jumper, J, connecting B to C, voltage is applied to terminals A and B, and the current is adjusted to twice the normal three phase value per leg. Readings of copper loss and impedance voltage are taken. Similar readings are taken with the jumper from A to C, and then with voltage applied to terminals A and C with the jumper from A to B.

The three phase copper loss will again be half of the sum of the three loss measurements. The three phase delta impedance voltage will be the average of the three single phase impedance voltage readings.

Copper Loss (3 phase) =

$$\frac{W_{J\text{-}BC} + W_{J\text{-}AC} + W_{J\text{-}AB}}{2}$$

Impedance Voltage (3 phase) =

$$\frac{V_{J\text{-}BC} + V_{J\text{-}AC} + V_{J\text{-}AB}}{3}$$

Zig-zag Grounding Reactor

The necessity of measuring core loss and exciting current on a 13.2 kv. three phase grounding reactor, without sufficient instrument transformers being available for testing, required the use of the above methods of determining these values by single phase measurements. It is apparent, however, that terminals A, B and C, Fig. 3, cannot be used for this purpose for the windings are so distributed and connected that all legs would be excited on each test,—one leg fully and the other two legs each half excited.

For this test, terminals D, E and F must be accessible. These give a straight star connection so that the method described with Fig. 1 may then

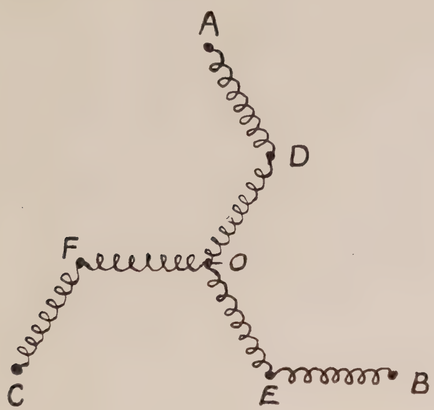


Fig. 3.

be used but the voltage applied single phase would have a value of two-thirds of the normal three phase voltage, A-B-C.

Three sets of readings are taken,—voltage applied from D to E, E to F and D to F, respectively. Three phase core loss, as before, will be half the sum of the three single phase loss readings. Normal three phase exciting current will be the average of the three readings taken divided by $\sqrt{3}$.

$$\text{Core Loss (3 phase)} = \frac{W_{DE} + W_{EF} + W_{DF}}{2}$$

$$\text{Exciting Current (3 phase: A-B-C)} = \frac{I_{DE} + I_{EF} + I_{DF}}{3\sqrt{3}}$$

Copper loss may be measured by single phase readings with voltage applied to terminals, D, E and F, in pairs, and with sections A-D, B-E and C-F, short circuited separately. The use of the single phase impedance voltage readings to determine three phase impedance under the conditions of a grounded line, or short circuit from line phase to neutral, appears considerably more complicated and such determination would not seem to be reliable in any case due to the interconnection of windings and the uncertainty of actual flux values in different magnetic circuits.

Analysis of Fault Conditions

Three single phase readings of core loss, taken as explained above on either star or delta connection, may be used to segregate the iron loss per leg and per yoke. The relative lengths of leg and yoke may even be calculated from the results. Comparison of the readings will also show whether loss in any one leg differs from those in the other legs, either in the iron or due to short circuited turns in the windings on that leg.

In one instance, where an old transformer had considerably higher core loss than the original value, it was thought that some stud insulation had failed. Analysis by the above method, however, showed all legs to have equal loss. Further analysis of iron losses showed that the increase was entirely in the hysteresis loss of the core, apparently a natural slow aging, and that there was no need for alarm as to the condition of the stud insulation.

In another case, two duplicate transformers were tested. One had much higher core loss than the other but an analysis, by these single phase methods, showed that all of the additional loss was in one of the outer legs. Segregating the eddy and hysteresis components of the losses by test at different frequencies, showed that all of this excessive loss was of the nature of circulating currents. The fault then was quickly located,—an error in winding connections on this leg of the transformer which caused appreciable extra

current to circulate through several turns of the high voltage winding.

Shell Type and Other Transformers

Up to the present time, the methods of test here described have been applied only to three phase core type transformers and reactors where the centre lines of all legs lie in the same plane. These methods evidently require some modification before being used for determination of core loss in shell type transformers, however, as the flux in some parts of the core would not be at normal value on this test and therefore the losses in these sections would not be normal. Nevertheless, it should be quite satisfactory to measure copper loss in this way in low reactance shell type transformers for the flux values then are very low and any errors probably would be negligible.

Before these methods may be applied to core type transformers which have unusual core forms, it would be necessary to study the flux conditions obtaining in the yokes but it is doubtful that satisfactory measurements of core loss could be obtained on such transformers. There would not appear to be any advantage in measuring the losses of a three phase bank of single phase transformers in this way where the units could easily be disconnected and measured separately. Experience in the application of these methods of test to three phase core type transformers has been very satisfactory, however, both for determination of losses and also in analysing conditions when investigating trouble and searching for faults.

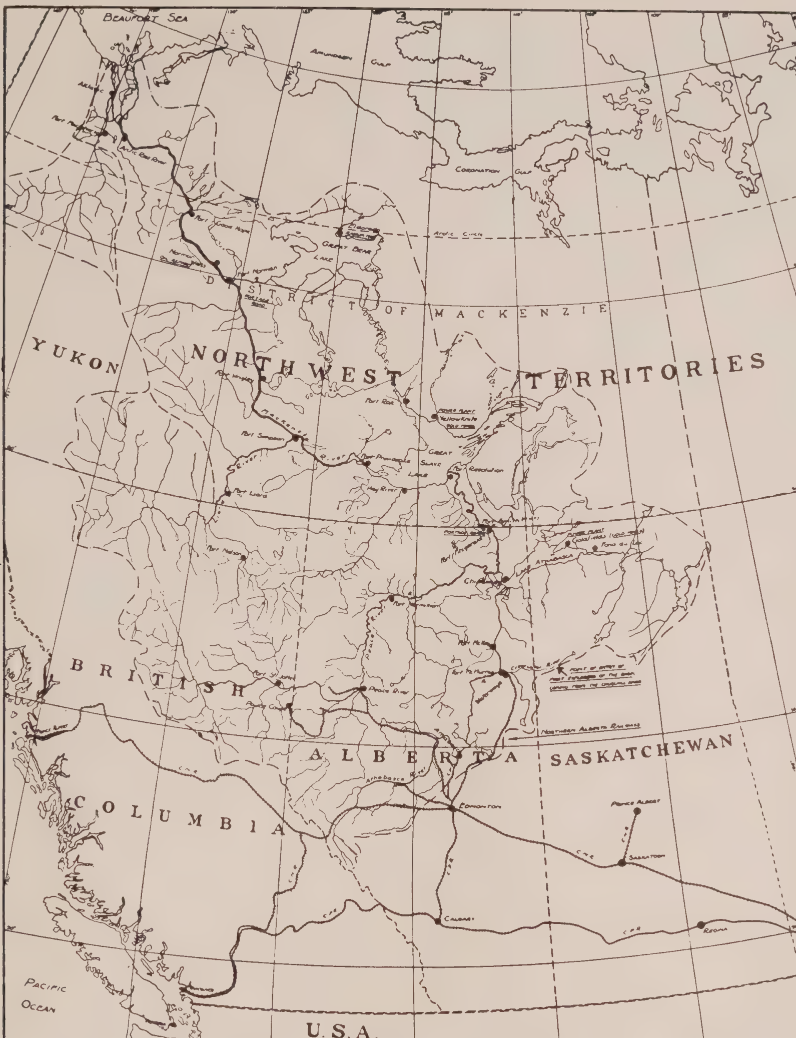
Construction North of 54°

Robert F. Leggett, Assistant Professor of Civil Engineering, University of Toronto, Toronto, Ont.

ALTHOUGH recent developments in the vast area of northwestern Canada formed by the Mackenzie River Basin are known to mining engineers, if only because of the much publicized Eldorado radium mine on Great Bear lake, to civil engineers the region still remains as a large space on maps of the continent and but little more. The distortions of map projections have probably led many to discount the size of the basin. Actually, the Mackenzie is one of the eight major river systems of the world, second only in size, in North America, to the Mississippi. Its catchment area is about 682,000 square miles, the St. Lawrence basin being only 498,000 square miles in comparison. From its source to its deltaic mouth in the Arctic ocean the Mackenzie is about 2,525 miles long, the Columbia river ranking third in length at 2,200 miles. And Great Slave lake, with an area of over 12,000 square miles, is the fourth great lake of the continent.

Extending from the 53rd parallel to the Arctic Ocean, the topography of the basin is featured by a central plain

From an Address delivered to the London Branch of The Engineering Institute of Canada, on December 12th, 1940.



THE MACKENZIE RIVER BASIN.

flanked by the western extremity of the Laurentian Shield on the east, and by the Rocky mountains on the west. First explored by Alexander Mackenzie in 1791, in one of the greatest canoe journeys ever made, the region retained its virgin character until well on into the present century. The trapping of fur bearing animals was the only encroachment of man into this vast area of the wilds. Hudson's Bay Company posts along the main waterways were the only permanent settlements. Transport was limited to movements along navigable waterways and to short journeys inland from the river banks.

The coming of the aeroplane effected a radical change, making contact with

the outer world regular and speedy, and permitting the study of large areas of otherwise inaccessible country with ease. The first flight into the North from Edmonton was made in March, 1921. In 1922 planes of the Royal Canadian Air Force started aerial survey work. To-day two well established aerial transport companies operate regular services along the Mackenzie as far as the Arctic from Edmonton, Alberta, and Prince Albert, Saskatchewan.

Prospecting, in the pre-cambrian rocks of the Shield, was greatly facilitated by aerial travel. As a result of the increased activity in prospecting, five gold mines are to-day operating on the north shores of lake Athabasca and Great Slave lake, while on Great Bear lake is the well known radium mine, now shut down. Other prospects are in course of development. Where previously Fort Smith, "capital" of the Northwest Territories, was the metropolis of the basin with a total population of about 400, to-day Goldfields on lake Athabasca has a population of about 1,000 and Yellowknife on Great Slave lake is about the same size, both thriving mining settlements.

The mills associated with the gold mines have a total capacity of 1,700 tons of ore per day; their construction involved the usual structural work encountered with mill buildings. Power supply was originally obtained from Diesel engines, but to-day the Box mine at Goldfields is served by a small water power plant on Wellington lake, power being delivered to the mine over a 22 mile 60,000 volt transmission line. In view of the nature of the country traversed, rocky and rugged with much muskeg, steel towers were used for the line with the longest spans practicable. In consequence, there are only 107 spans in the whole line. Water for the plant is diverted from Tazin lake through a 16 ft. by 12 ft. rock tunnel 1,100 ft. long, to Mud lake. Three open cuts, totalling 77,000 cubic yards of excavation, provide a water channel from Mud lake to White lake, the level of which has been raised 15 ft. by a log crib dam 350 ft. long. Serving as the forebay, this lake is tapped by another tunnel, 15 ft. in diameter leading to two 10 ft. woodstave pipes, through a 14 ft. wye piece, and so to the power house. At present a flow of 500 cu. ft. per sec. is used to generate 3,300 h.p. under a 75 ft. head, but all the permanent works have been designed and constructed for an ultimate development of 6,600 h.p. using 1,000 cu. ft. per sec.

Constructed in 1937-38 the plant called for no unusual construction methods but it did necessitate special transportation arrangements. Every conceivable means of transport in the north was employed at some time during the progress of the job, even to dog teams in the winter for hauling lumber over the ice. The greatest difficulties were encountered in connection with the Mud lake tunnel and open cut excavation. A road was constructed from lake Athabasca to the power house site, but diligent search failed to reveal any route from there to Mud lake, either by land or by water, that would provide a road that could be economically constructed in the time available. All equipment and supplies for this section of the work were therefore flown in to the site. Handled in this way, in several large multi-passenger planes, were 300 tons of oil, 250 tons of gasoline, food for 40,000 man-

shifts of work, three two-ton trucks, three 360-cu. ft. compressors, eighteen dump ore cars, a four-ton gasoline locomotive, and even a three-quarter yard Diesel shovel, this being the largest size that could be dismantled into parts sufficiently small for transport by air. The cost of this unusual transport job was $48,000, the total transportation cost for the whole project, from the railhead at Waterways, being $229,000. Labour costs amounted to $457,000, the complete installation costing in all $1,511,600. This figure should be considered only in relation to the extremely isolated location of the job, and the fact that a good deal of the work had to be carried out in winter.

There has just been completed, to serve the mines in the Yellowknife area, a second water power plant of 4,700 h.p. capacity on Prosperous lake, the power house of which is located on the Yellowknife river, below the lake. Water storage is obtained in nearby Bluefish lake, the level of which has been raised 10 ft. by a rockfill crib dam about 500 ft. long, the penstock being supplied through a 900 ft. rock tunnel. Surge tank and penstock are of woodstave construction, the latter being 1,800 ft. long, giving a head of 105 ft. at the power house. Power will be delivered to the mines over a 22 mile transmission line, also constructed with steel towers and unusually long spans. Transportation problems have been relatively easy since all material could be delivered almost to the power house site by water with only one transfer from the regular freighting service on Great Slave lake.

The precious metal mines are all located in that part of the Mackenzie basin formed by the edge of the Laurentian Shield. To the west, but unconformable with the pre-cambrian rocks of the Shield, are exposures of cretaceous and palaeozoic rocks in which occur coal and oil deposits. One of the coal beds exposed on the banks of the Mackenzie river has been burning slowly ever since it was first seen by Mackenzie in 1791. Although the coal has been little used as yet, the Imperial Oil Company Limited have a small oil refinery located at Norman Wells, about 100 miles south of the Arctic Circle. Their Discovery Well No. 1 was completed in 1921 but lack of a market for the oil delayed further progress. Recent mining operations have provided a small market and led to the building of the refinery in 1939. The new unit has a capacity of 840 barrels of crude oil per day; an aviation gasoline and light Diesel fuel are produced. It operates for about three months of each year, all equipment near the river being hauled up high on the bank before the winter sets in so that it shall be clear of spring flood waters. Flood water level may be more than 50 ft. above normal water level, due to the fact that the river flows northwards and so thaws out first at its source; this unusual feature affects all river-bank development.

Construction of the refinery was interesting in that the ground at the site is frozen to a depth of over 50 feet, thawing out in the short summer season to no more than 18 inches below the surface. Grading operations for construction consisted of "skimming" off this thawed layer, and using it to form a foundation area raised above the general level of the surrounding ground. This raised section of thawed out earth was surrounded by a stone filled trench

which prevents surface drainage from entering the soil and so freezing during the winter. As the untouched ground beneath the fill will never thaw, since the sun never reaches it, all frost heaving has been prevented. All equipment for the refinery had to be brought in to the site by water, the heaviest pieces being limited to 10 tons in weight and 10 ft. by 35 ft. in size. The fractionating tower was 35 ft. high and 4 ft. in diameter and so was shipped complete. All large piping was shop fabricated; storage tanks were of bolted construction.

It will be appreciated that apart from the surmounting of climatic difficulties such construction as has been carried out in this great area has presented few unusual features. Contrary to usual experience, it is transport rather than building operations that presents the problems. Aerial transport has been mentioned; it provides all mail and light express service, but ordinary freight and heavy equipment have to be brought in by water, during the very short summer season of open navigation, always less than six months. The Northern Alberta Railway provides access to the basin from Edmonton by means of their Peace River lines and that to Waterways on the Clearwater river near its junction with the Athabasca river; the latter is the route used for all but local Peace river shipments. From Waterways to the Arctic ocean at Aklavik the river route is about 1,600 miles long and in this distance the fall in water level is only 820 feet. Very fortunately 125 feet of this drop occur in a series of big rapids at Fort Smith, N.W.T., and these provide the only serious impediment to navigation in the whole course of this long journey to the sea. Two sixteen-mile portage roads have been built around the rapids on which operate competing fleets of heavy duty trucks and tractors capable of handling practically anything that can be loaded on to river boats from railway cars at Waterways.

The several water transport organizations have each to maintain two fleets of vessels, above and below the Fort Smith rapids respectively. The service thus provided has a special interest in that it is now one of the very few inland water transportation systems in this continent unaffected, as yet, by competition from road or rail. The economic problems are as unusual as the service provided. Practically all freight moves one way only, to the north; all freight for the Northwest Territories has to be portaged sixteen miles; and all freight for the year has to be moved in less than six months—these are some of the problems that complicate operations.—*The Engineering Journal.*

The Electric Utility in Canada

By Wills Maclachlan

(Continued from October)

The tremendous potential power of Niagara falls was always a challenge and many attempts had been made to develop a plant that would make power available. In the late 1880's extensive studies were carried out on this idea, the thought ranging from supply of water power to individual mills and allowing them to develop their own power, or to a central station supplying power to the mills. Quoting from Edward Dean Adams, one who was very interested in this development, we find the following:

"When the original development of the Niagara Falls Power Company was contemplated, we had no idea what shape the power would eventually take—whether it would be electricity, compressed air, water under pressure or what not. We did determine to make an exhaustive investigation, to consult the best engineering talent in this country and in Europe and after that to map our future course. Of one thing we were certain, we would use water from the Niagara river above the falls and discharge it again into the river below the falls, and no matter what system of power development was adopted, a tunnel was required. In order to save time we started to build a tunnel before we came to any conclusion about the type of equipment to be used in the power house."

Would financial men of 1940 go ahead with such a project under such conditions? After very considerable investigation by the International Niagara Commission which met in London, England, and upon which was Lord Kelvin, on May 6th, 1893, a decision was arrived at to use alternating current 3-phase at 25 cycles and the orders were placed for a 5000 h.p. generator.

Two stories are current as to the choice of 25 cycles; one that this was set by the most efficient speed of the hydraulic turbine, the other that it was a compromise between the frequency of 40 cycles then common in Europe and 10 cycles, the most efficient for the then rotary convertors to carry railway load. Ranged on the side devoted to direct current were Edison and Kelvin and on the alternating current side were Westinghouse and Ferranti. So was launched the development of power at Niagara Falls and the possibility of the transmission of that power.

A few earlier cases of transmission of power had been carried out, such as that of the Telluride Power Transmission Company in Colorado during the winter of 1890-91. These cases, however, were much smaller than at Niagara.

It is difficult to state which was the first transmission of power in Canada, but certainly the power plant at Ste. Narcisse transmitting power to Three Rivers was among the earliest and very probably was the first in the British Empire to transmit power a distance of 18 miles. This plant went into operation between 1894 and 1895. It is interesting to see the early power plant and transmission line and also to see the present development at this point. Copper from this early transmission

line is used in making the bronze medals of the Canadian Electrical Association for award to employees of public utilities in Canada for successful cases of resuscitation from electrical shock.

Owing to the fact that increased power was needed in the city of Montreal and to the fact that there was considerable potential power on the Ste. Maurice river, the Shawinigan Water and Power Company was incorporated on January 5th, 1898, to develop power at Shawinigan Falls, and construction was started in the winter of 1899. Hydraulic power was first delivered to the Aluminum Company of Canada on July 1st, 1901, and following the practice of those days an endeavour was made to locate near Shawinigan, industries, particularly of a chemiral character, which would require considerable amounts of power. Transmission of power at 50,000 volts to Montreal, 85 miles distant was completed on March 1st, 1903. As in all power companies operated on the river, the storage of water and the balancing of load between power plants has received careful and considerate investigation by the officers of the Shawinigan Power Company during the whole of its existence. This has necessitated dams and power plants over all the reaches of the Ste. Maurice and some of the more modern developments are interesting to view.

One can hardly think of the Shawinigan Company without associating with it the name of Julian C. Smith. Born in 1878 in Elmira, N.Y., he completed his undergraduate education at Cornell. After having experience with Wallace C. Johnston at Niagara Falls he came to Shawinigan in the early years of this century. He had great ability not only in purely engineering matters but also in the many problems with which a chief executive has to deal, marking him as one of the outstanding men in this field in Canada. However, to those who knew him Julian C. Smith will be remembered best for his assistance to engineering organizations, counsel to Universities and quiet guiding advice to those who sought his assistance. On June 24th, 1939, Canada lost a man whom it could ill afford to lose.

Hamilton, Ontario, had the usual experience of cities in the development of power—a local steam plant serving a local community. About 1896, the Cataract Power Company was organized to develop power at De Cew Falls. Water rights were completed in 1897 and the plant put in operation and power transmitted to the city of Hamilton in 1898. It is interesting to note that the engineer who built the power plant at De Cew was a Canadian born in Brantford, educated as a civil engineer and spent his early life in railway construction. Lieutenant-Colonel Reuben Wells Leonard is probably known to Canadians and particularly to the Universities of Canada as a benefactor in many fields, but as a young engineer he was the builder of the first plant on the Canadian side of Niagara falls, of the plant at De Cew Falls and later the Kakabeka plant of the Kaministiquia Power Company near Fort William.

It was not a simple thing to convince manufacturers, even in 1900, that electrical power was as satisfactory as their steam plants. I quote from a statement of W. G. Angus who was connected with the Cataract Power Company from the building of De Cew.

"An interesting thing happened at what was known as the Ontario Coloured Cotton Company when we were trying to get the business. They got a slug of water over from the boilers and punched the end of the high pressure cylinder and shut down the mill and they were in trouble. I had up in the old Hamilton Electric Light Company a large motor. I took it down there and put it in the mill in the loom room on the first floor and eliminated the belting that ran back into the engine room. It was a question whether it would carry the mill and we started it up and made a temporary job of it. We got the mill running and it ran, showing a pretty considerable saving between that and the engine. After they got their engine fixed and the question came up to get the motor out, I went to Mr. Dexter several times and he always put off letting the motor go. Finally the truth came out that the good speed regulations in the electric drive had demonstrated a considerable saving in what they called seconds. That is, the steam engine varies in speed up and down, especially old machines. He found he had eliminated a lot of seconds by the close regulation in speed which he got by the electric drive. That got us a big customer."

It would be impossible to cover the many developments of the early days of this century. The Canadian Niagara Power Company, Ontario Power Company and Toronto Power Company were building plants on the Canadian side of Niagara falls. Power was transmitted to the city of Toronto in the fall of 1906.

Owing to the growth of load in Winnipeg, power was developed at Pinawa Channel and transmitted to Winnipeg in 1906.

We have seen how the scientific truths enunciated by research workers were taken by inventors and the results of their labours welded into small power plants to serve small towns or the small part of a large city. We have seen where these plants have been consolidated together due to the possibility of primary voltages up to 2200 volts. Later, large blocks of power were developed and transmission lines with voltages up to 50,000 carried out, but for the most part, carrying these large blocks of power from the point of generation to a large distributing point.

Investigations were now carried out in a number of points, which resulted in the tying together of a number of power plants by transmission lines and serving a number of towns or cities. About 1909 such a system then known as the Electric Power Company was organized by the late Cecil B. Smith. Mr. Smith was a civil engineer, a professor of McGill University, the first Chief Engineer of the Hydro Electric Power Commission and at the time under consideration was a consulting engineer. By developing a system in central Ontario, tying together a number of power plants on the Trent river, a system was organized to supply the district bounded by Oshawa on the west, Napanee on the east and Tweed, Peterborough and Lindsay on the north.

A very similar type of system was organized a few years later by a recent graduate in Engineering of McGill, J. B. Woodyatt. This tied together a number of power plants in the southern counties of Quebec and fed through a network of transmission lines such towns

as St. John, Drummondville, Sherbrooke, Ste. Hyacinthe, etc.

Possibly one of the most celebrated networks was organized by the late Sir Adam Beck; this network being the Niagara system of The Hydro Electric Power Commission. Taking power from the Ontario Power Company at Niagara Falls a one hundred and ten thousand volt transmission line was extended to Dundas and then to Toronto, Guelph, London and a number of other cities in southwestern Ontario. Many of us well remember the first Sunday in September, 1910, when power was first turned on to this system for test and later that fall for commercial service. In mentioning The Hydro Electric Power Commission, it is impossible not to associate with it the name of Dr. F. A. Gaby. This Engineer gave richly of his experience, training and ability in the development of this now vast system.

With the growth of the requirements of the Province, the meagre beginnings in 1910 were greatly augmented about 1917, when construction was started on the Chippawa-Queenston development where instead of just using the drop of the water at the falls alone, use was made of as much as possible of the drop from lake Erie to lake Ontario. The requirements for power at the head of lake Superior were the reason for the development of Nipigon power plant on the Nipigon river. More recently Chats Falls was built on the Ottawa river above the city of Ottawa and using that power and other power purchased from the Gatineau Power Company a transmission line at 220,000 volts was built to the city of Toronto, reaching it at the town of Leaside where an extensive substation and distribution centre was installed. In this way, from small beginnings, a tremendous power organization to supply power to the Province of Ontario has been developed.

On almost like scale, developments have been carried out in the other provinces.

One comparatively recent extension of electrical service, is the extension of electrical service to the rural communities. Now on many farms in Canada, electrical service is almost taken for granted. Lighting, milking and many other services are carried out electrically.

This huge electrical utility is in the able hands of Dr. T. H. Hogg as Chairman and Chief Engineer. Many of the power plants we have seen came under his supervision when he was Chief Hydraulic Engineer. He is now giving to the people of Canada the benefits of his international engineering experience and to the engineering profession the guiding hand as President of the Engineering Institute of Canada.

It would not be a true statement to say that all of this work has been carried out without setbacks, without vast problems to solve and particularly without trying to cope with the forces of nature. In 1909 a bad ice jam formed in the lower Niagara river, the water at the Ontario Power Company rose 42 feet, entirely swamping the power plant. At this time, I was electrical superintendent of a consumer of the company. We had had certain short shutdowns prior to this and I remember well the morning, calling up the superintendent of the Ontario Power Company and asking him how long we would be off this time and receiving the advice that we would probably be

off six months. However, by making certain arrangements, they were able to supply power very much sooner than six months. In 1938 another ice jam formed in the river and again the Ontario Power Company was not only flooded out but the power house was jammed with ice and steam shovels had to be used to remove the ice from the power house. By the skill of local engineers, a method of vacuum drying was put into effect and it was possible to dry out the generators and put them back into service without rewinding, excepting in one case where the generator was almost due for overhauling.

In 1898 an extremely bad sleet storm hit Hamilton and Toronto, pulling down structures of the local utilities. Wires, poles and trees made a terrible mess on the streets. This type of trouble has been taken care of to a certain extent by more solid construction and tree trimming. However, at times snow piles up about 2 feet in diameter on some wires in rural districts, putting a tremendous load on the wires and at times, as in Toronto in 1926, sleet is king. We are also subjected at times to bad wind storms or hurricanes coming through parts of Ontario and although towers of transmission lines are strongly built, yet at times they cannot withstand the pressure placed upon them.

It is at these times of trouble that the power organization is tried to its utmost; then it is that linemen, operators and maintenance men show what they are made of, many times working for extremely long periods in the worst kind of weather, to try to restore service or to maintain services, which is the ideal of all electrical utilities.

Mining operations in the Cobalt field in 1907 required compressed air and it was not long before a power plant was in process of construction on the Montreal river and another on the Matabitchouan river. These plants were the starting of the system of the Northern Ontario Power Company, supplying power first to Cobalt, Haileybury and New Liskeard and later the gold mining camps of Timmins, Porcupine and Kirkland Lake. At a more recent date a large plant was built on the Quinze river in Quebec and fed into this system. This system was also extended to supply power to the copper and gold mines of northern Quebec.

One cannot think of the Northern Ontario Power Company without recalling the great service of its creator the late J. Homer Black—telegraph operator, school teacher, railway superintendent, power superintendent and executive. It will be a long time before the North will forget what it owes to this leader.

The Hydro Electric Power Commission purchased a plant that was being completed by the Abitibi Power and Paper Company, some 76 miles north of Cochrane at Abitibi Canyon, and transmitted this power over a high tension transmission line to the city of Sudbury. Many other power developments have been carried out in the far northern parts of Canada to supply the growing needs of these mining camps and cities. It is very interesting to view a more recent development in the building of transmission lines through the far north bush.

For very obvious reasons I have not used maps and so have been prevented from showing the growth and completeness of the electric utility in Canada. I have also refrained for the same reasons

from giving a description of the developments in the west and east maritime provinces of Canada.

It could have been possible to show the development of a high standard of construction of the electrical plant in the cities of Canada, where some substations look more like libraries and others like modern residences, except when one sees the back yard.

It would not be fitting to close without mention of the admirable group of men and women who are the backbone of the utility industry. You have seen the construction linemen at work and I can assure you that the operating lineman is a man, many times tried and never found wanting. The maintenance men, operators, load despatchers and system supervisors and a host of others, are serving twenty-four hours a day and three hundred and sixty-five days a year. Many even eat their Christmas dinner on the job so that service will be maintained. Is it small wonder then that those of us who have lived our lives in utility work are proud of these men, of their esprit de corps and resourcefulness in emergency?

Canada is rich in water power and this water power will no doubt be developed so that cities may be served, the industrial plants supplied with power and the rural communities receive many of their benefits from the use of electricity. All of these things, however, will come about by the leadership of engineers and utility executives upon whose shoulders will be the responsibility of directing that host of linemen, operators, maintenance men, engineers, draftsmen and others who will make possible the application of the truths of science for the benefit of mankind. "May wisdom teach them what to do as cleverness has taught them how to do it."

Some Ups and Downs of Forty-Six Years

By George D. Y. Leacock, President, Moloney Electric Company of Canada Limited, Toronto

I STARTED in the electrical business forty-six years ago this month, and therefore I will be celebrating my jubilee in four years—without the gold. As I look back over these forty-six years the time seems to have passed very quickly, in fact so quickly I have not had time to fix the switch for the cellar light. I started in the electrical business forty-six years ago when I first left school. Some of my friends say to me "You must have been very young when you graduated." You will notice I did not say "graduated." I said, "left school."

It would take too long to describe all the positions I have occupied in these years, because they were positions on step-ladders, under beds, putting in base plugs, crawling in and out of boilers, and, in fact, almost every position that it is conceivable to get into. People often ask me how the cost of lighting compares with that of

earlier days, and seem to think it is much cheaper now. I can see very little difference. One could get fairly well "lit up" for twenty-five cents and stay in that condition pretty well all evening. I am often asked if we worked longer hours in the old days. All I can say is, that I am very glad they didn't get around to inventing daylight saving until recent years.

Some of my friends ask me if I would advise them getting their boys in the electrical business, and my answer is always the same—"Let the boys find out for themselves." It might take them a little time to make up their minds. In fact after forty-six years I am like a cat up a tree, wondering why I went up and if I can get down without help, but at least while I am up there people look up to me. And the same goes for all engineers; the laymen really think we know something, and who can tell—maybe we do.—*Electrical News and Engineering.*

Spectroscopic Analysis

Use In Engineering Industries

THE examination of steels and non-ferrous metals for important constituents present only in very small quantities is being carried out on an ever-widening scale by means of physical tests made with the spectroscope rather than by chemical analysis. The rapid routine control of steels is an outstanding example; with the aid of a works instrument recently introduced the testing can be done with surprising speed by an intelligent but unskilled lad after only a few days' practice.

Different chemical elements burn with flames of different colours. Thus strontium burns with a bright red flame, copper with a green, sodium with a vivid yellow flame, and so on. If these flames are visually examined after their light has been passed through a prism, the colours are seen to be due to brilliant coloured lines which are really images of the slit of the instrument, through which the light is first passed. Each such coloured line is due to radiations of light having different wavelengths, the measurement of which—made with the spectroscope—gives an infallible clue to the identity of the substance. Metals which, like incandescent steel, burn "white" have a very complex spectrum, but nevertheless contain coloured lines which can be quickly identified with a modern instrument.

Hence it is not difficult to understand that such a chemical "stethoscope" is finding general adoption in engineering and metallurgical fields, especially as great improvements in construction and design during the last few years have made available works instruments which are portable and simple to use, and give a high order of accuracy in both qualitative and quantitative work.

Accuracy Attainable

It was stated recently at the Institute of Metals by F. Twyman, F.R.S., that the consistency of spectro-chemical analysis of non-ferrous alloys is from

2.5 to 7.5 per cent in the percentage of minor constituents, according to the nature of the alloy. In the case of steels, it is possible within a minute or so of obtaining the sample to discriminate between two steels containing only 0.24 and 0.19 per cent of vanadium. Rough quantitative measurements of manganese in steel between 0.6 and 1.4 per cent, and the estimation of the manganese in sample in less than one minute with an accuracy sufficient for prescribing the most suitable heat treatment, are other examples of the capabilities of the spectroscope. The extensive applications which are being made at the present time are quite remarkable, the accuracy of spectrochemical analysis having increased by some four times during the last five years.

In the Spekker Steeloscope, a workshop spectroscope designed for the rapid estimation of nickel and other metals in steel and for sorting and checking steel stores generally, a small piece of the alloy to be tested is used as the negative pole of an electric arc. The light from the arc is spread out by prisms within the instrument and is seen in the eye-piece as a series of coloured lines. If the presence of molybdenum, for example, is being looked for, a slide on the eye-piece is moved along until it clicks into a position marked for this metal, when one of its distinctive lines will be seen in the middle of the field. The quantity present in the steel is gauged by the brightness of the coloured lines as compared with neighbouring lines due to the iron; by comparison with standard samples the amount can be estimated very quickly. A somewhat similar instrument will reveal as little as 0.1 per cent of lead or iron in brass scrap.

In a communication from the Spectrographical Section of the Naval Ordnance Inspection Laboratory, Sheffield, to the Iron and Steel Institute it has been stated by F. G. Barker that several samples of brass are often received together for complete analysis to a specification which limits the impurities to very small amounts. Whereas the chemical analysis of a batch of a dozen samples would occupy one man about a week, the spectroscopic method enables the work to be done within three hours.—*Trade and Engineering.*

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Daylight Saving Time

MANY municipalities of Ontario are loyally complying with the Power Controller's order and remaining on daylight-saving time this year in order to make their contribution to saving power for the war effort. Citizens who like the extra hour in bed in the morning are finding it unpleasant of course to get up in what appears like the "wee sma' hours". However a better understanding of the facts respecting daylight-saving and standard time should enable us to take at least a more philosophical attitude.

Those who argue in favour of standard time and are opposed to the use of daylight-saving time appear to assume, though they may not express it, that standard time has been divinely appointed and that any interference, therefore, constitutes an affront to an all-wise Providence. They evidently do not recognize the fact that the standard time system is itself a man-made convention, developed and introduced by Sir Sanford Fleming, who also suggested the arrangement of time zones that has since been adopted by the various countries of the world. In Canada there are six of these time zones known respectively from east to west as Atlantic, Eastern, Central, Mountain, Pacific and Yukon, and these divisions have been made entirely for the purpose of convenience in measuring and comparing time.

The earth turns through a complete revolution from midnight to midnight in twenty-four hours, i.e. 15 degrees per hour. The whole surface of the earth is marked off by imaginary lines known as meridians, running from pole to pole and spaced one degree apart. The line which runs through the borough of Greenwich in England is called the zero meridian, and the other lines are known by the number of degrees that they are from this base line up to 180 degrees east or west of Greenwich. The measurement of the position of any place by meridians is known as longitude.

To have every time zone just one hour later than the one preceding it would require that these zones each be exactly 15 degrees wide. It has been found advisable, however, to vary the boundaries of some of these zones so as to include certain towns or cities

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The purpose of the Bulletin is to furnish information regarding the Hydro-Electric Power Commission; to provide a medium for the discussion of "Hydro" matters and to maintain the co-operative spirit between municipalities, as well as between municipalities and the Commission. Articles of interest are invited for publication.

or certain islands as a matter of convenience.

As the earth revolves the sun sets four minutes later for each degree of longitude. The province of Ontario extends from about longitude 74°-20′ to 95°-10′ West, or nearly 21 degrees, giving a range of time of sunset of about 84 minutes.

Eastern standard time is based on the 75th meridian, five hours later than Greenwich, and this zone normally should extend from 67°-30′ to 82°-30′. By the adopted convention, however, Eastern standard time is extended from the 68th nearly to the 90th meridian, and therefore is used in Windsor, Sault Ste. Marie, Port Arthur and a large part of Northern Ontario, which would not normally be included in this zone. From the eastern boundary of Ontario to Port Arthur the difference in time of sunset is about one hour. As contrasted with communities in the extreme east of Ontario or the city of Montreal, the city of Port Arthur, therefore, enjoys, even under standard time, an extra hour of daylight in the evening.

The inclination of the earth's axis is the cause of wide variation in the proportion of day and night during the year, giving in high latitudes long summer days and long winter nights This is the chief factor in the length of daylight in different places. It thus makes daylight-saving in higher latitudes more necessary in the winter in so far as overlapping of evening electric power loads is concerned.

Other factors entering into the problem result from the elliptical shape of the earth's orbit and a two-cycle-per-year variation in the sun's crossing of the meridian due to the inclination of the earth's axis to the plane of its orbit. The net effect of these factors is to delay both sunrise and sunset during winter months, but only for a few minutes at most.

The central reference point for the city of Toronto is the meteorological observatory on Bloor street with latitude 43°-40′ North, and longitude 70°-24′ West. In Toronto the winter mornings continue to darken until about January 6th, but the evenings

begin to lengthen about December 12th.* These conditions would be different for other municipalities. The fact that Toronto lies several degrees west of the standard 75th meridian, delays the time of sunrise and sunset about seventeen and one-half minutes as compared with the time these events take place at the same latitude on the standard meridian.

Now with regard to the effect on the power demand of the extension of daylight-saving time ordered by the Dominion Power Controller, a saving is effected in two main ways. For the individual municipality the result of the extension of daylight-saving to the winter months is to minimize the overlapping of the domestic and commercial lighting demands with the industrial power loads. In most municipalities, especially those having a large industrial demand, the overlapping of these loads on dull days during the early part of December creates the peak load for the year, for which generator and transformer capacity must be provided and the purchase, installation and maintenance of the necessary equipment paid for in the power bills.

In addition to the reduction in demand secured by avoiding overlapping which would, of course, result if all municipalities were on daylight-saving time, a further reduction in the combined demand of the municipalities can be obtained by diversifying the time at which the peak occurs in different municipalities. This increased system diversity, which results in lowering the aggregate peak, can be secured if certain municipalities are on daylight-saving time while others remain on standard time. Municipalities which retain daylight-saving time for the winter benefit by a reduction of their peak load on which their power bills are based. All municipalities benefit by the reduction in system costs resulting from the improved diversity and lessened system peaks. Careful estimates indicate that the saving in aggregate peak loads during last winter amounted for the southern Ontario systems to about 75,000 horsepower. This was put to use and became a valuable contribution to Ontario's war effort.

Due to ever increasing demands of power for war purposes it may be necessary to impose further restrictions upon the use of electricity. Hearty co-operation of citizens in daylight-saving regulations and consistent avoidance of wasteful and extravagant use, especially during the late afternoon and early evening hours of the months from November to February, will ease the situation and may postpone the imposition of more troublesome regulations respecting the use of electricity such as were adopted during the last war.

*See curves of Sunrise and Sunset at Toronto in *The Bulletin*, October, 1941, p. 320.

Luminaires

By H. F. Davidson, Testing Engineer, H.E.P.C. of Ontario

THE need for improvement in artificial lighting at the present time is so widespread even in recently built buildings that it points to the necessity of a more scientific approach to the lighting problem. The luminaire is the tool by which the illuminating engineer converts the raw material, light, into the finished product, illumination. It is only by the selection of the most suitable type of fixture and the proper application that satisfactory illumination can be provided. The object of this article is to give the layman a better understanding of the types of lighting fixtures in use to-day and what can be expected from them.

The Purpose of Luminaires

By definition, "A luminaire is a complete lighting unit consisting of a light source, together with its direct appurtenances, such as globe, reflector, refractor, housing and such support as is integral with the housing."[1]

Light is emitted in all directions from a bare lamp. This type of distribution is not desirable or economical for ordinary applications hence the use of luminaires to control the light. The control of the light from the bare lamp includes not only the control of the direction or distribution but also the control of brightness and colour. Some decorative value is often advisable, the amount depending on the particular application. The major function, however, for other than purely decorative luminaires, is to fulfil the requirements of the eyes for reasonable ease of seeing.

Types of Luminaires

There are, in general, four types of luminaires classed according to the manner in which the light is distributed.

1. Direct
2. Semi-direct
3. Semi-indirect
4. Indirect.

The design and appearance of luminaires and their installation details may vary considerably but the basic method of distribution corresponds to one of the above types. A lighting system may be composed of a combination of more than one type of luminaire for example, a store may have indirect luminaires to provide general illumination and direct luminaires recessed in the ceiling over the display counters to provide high level illumination for the merchandise.

The quality of the lighting is governed to a large extent by the type of luminaire employed. The quality of the lighting refers to the freedom from glare, freedom from sharp shadows, the distribution and diffusion of the light and the colour. The quantity of the light refers to the amount of illumination (foot candles) on the working plane. Both the quality and quantity of the light are important where comfortable conditions are to be provided.

Direct Lighting Luminaires

Direct lighting luminaires distribute 90 to 100 per cent of the light output in angles below the horizontal. Typical examples of direct lighting luminaires

[1]Illuminating Engineering 36, No. 8, p. 832, September, 1941.

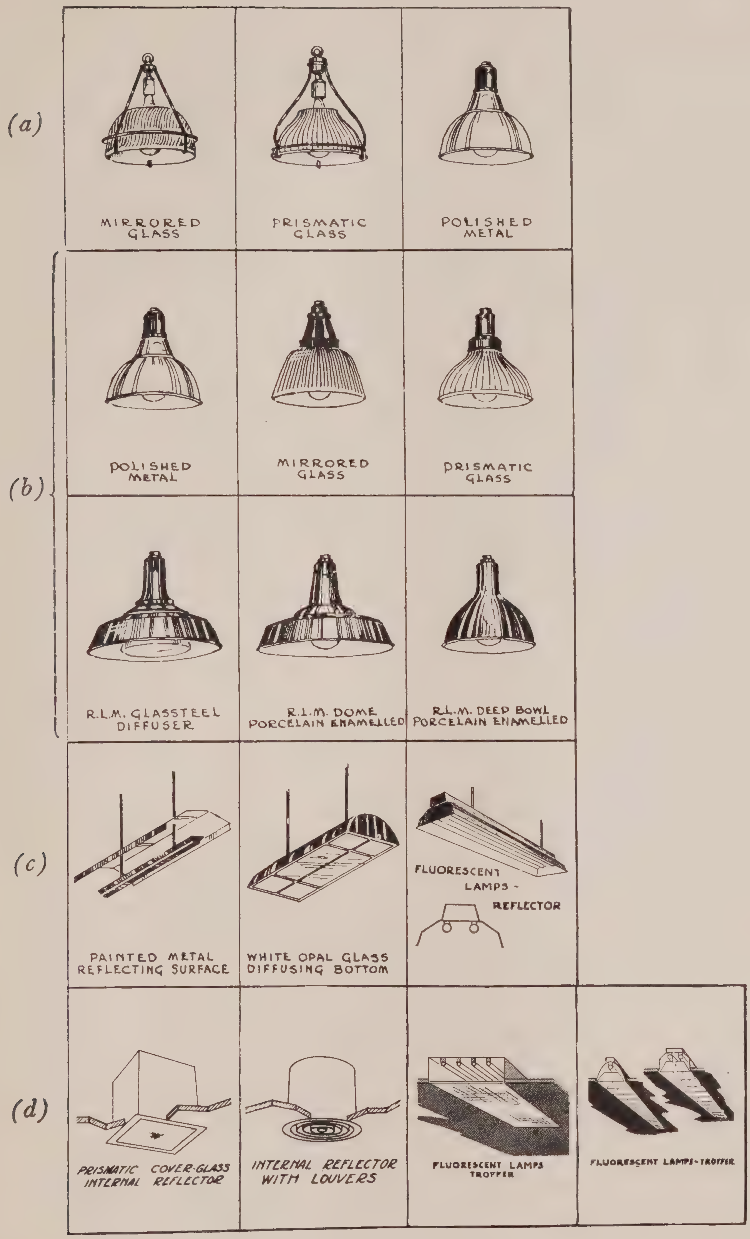


Fig. 1.—Typical Direct Luminaires.
(a) High-bay luminaires.
(b) Distributing luminaires.
(c) Large area diffusing luminaires.
(d) Recessed luminaires.

are shown in Fig. 1. Practically all industrial lighting is provided by the direct type of luminaire. These may be concentrating, distributing or large area diffusing reflectors depending on the manner in which the light is distributed by the reflector.

Concentrating or high-bay reflectors are used for high mounting heights. The reflecting surface is highly polished to give accurate control without diffusion. The reflectors most commonly used have reflecting surfaces of mirrored or prismatic glass or polished metal.

Distributing reflectors are used for average mounting heights of the order of 10 feet. The mounting height is the distance from the floor to the plane of the lamp filament. The R.L.M. dome, prismatic glass and glassteel diffuser are the most common reflectors in this group. The R.L.M. dome and glassteel diffuser have reflecting surfaces of porcelain enamel. Deep bowl reflectors are also used, the most common being porcelain enamelled steel, polished metal, prismatic and mirrored glass.

Large area diffusing luminaires usually take the form of a metal canopy with or without a diffusing glass bottom. They provide high illumination over tables or benches without the high source brightness of smaller luminaires. This makes them suitable for use where the surface of the work is more or less specular and would cause reflected glare if high brightness reflectors were employed.

Direct luminaires also find many applications in commercial lighting where the high utilization is used to provide high level illumination economically. They are known as "downlights" and usually consist of a reflector in a housing recessed in or mounted on the ceiling over the area to be lighted. Where there is likely to be high brightness in the field of view the downlights are equipped with louvers. With the advent of fluorescent lamps there have been many installations where the luminaires are recessed in the ceiling in rows called "troffers". The lamps are shielded with louvers or diffusing media to prevent uncomfortable brightness in the field of view. Flourescent lamp troffers are suitable for office as well as commercial lighting as they cover a much larger area of the ceiling and therefore provide more diffuse illumination than tungsten lamp "downlights".

Semi-Direct Luminaires

Luminaires which distribute 60 to 90 per cent of their light output in angles below the horizontal are called semi-direct. Semi-direct luminaires for use with incandescent lamps are almost entirely of the totally enclosing type made of white diffusing glass or prismatic glass. Luminaires of this type for use with the flourescent lamps are made entirely of metal or combinations of metal and glass or metal and plastics. Typical examples of semi-direct lighting luminaires are shown in Fig. 2.

Semi-direct luminaires are suitable for small stores, corridors, washrooms, etc., where the degree of refinement is not important and where there is no critical seeing to be done for long periods of time. This type of luminaire is sometimes used for office and schoolroom lighting where the capacity of the wiring or other limiting considerations call for a high efficiency at the expense of eye comfort. When

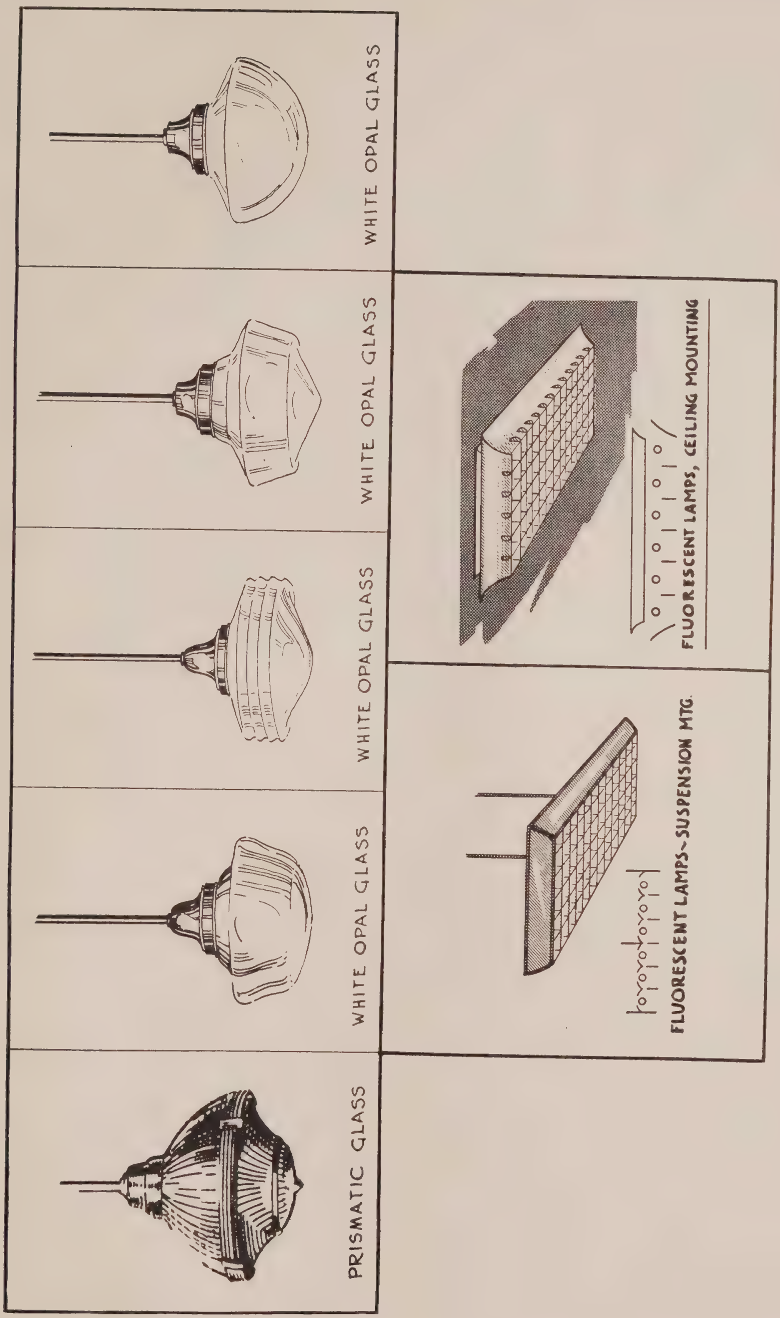


Fig. 2

used in offices and school classrooms the diameter of the glassware should be large enough to limit the brightness of the visible parts to 2½ candles

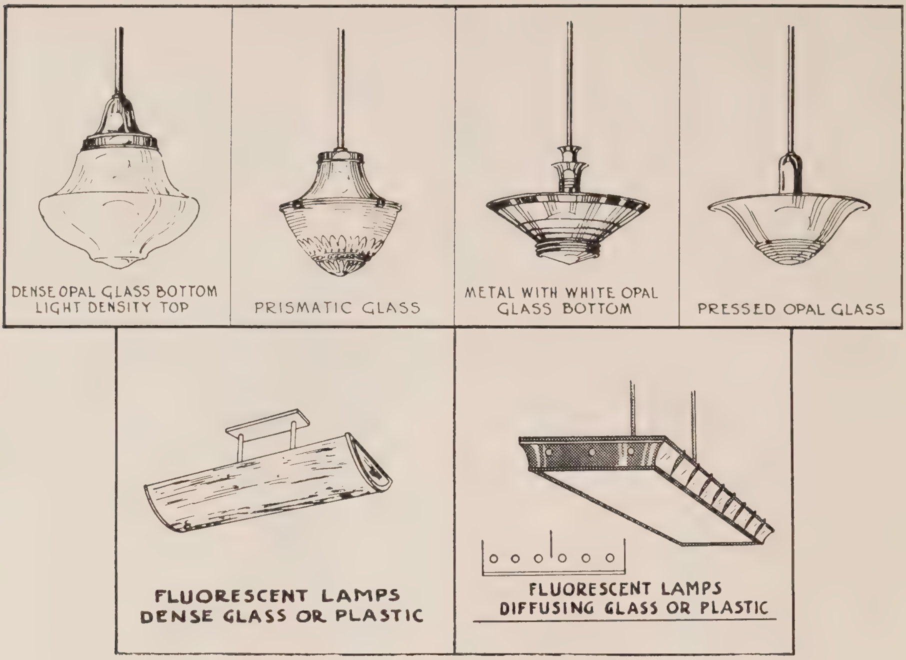


Fig. 3

per square inch or 1130 foot-lamberts.

Semi-Indirect Luminaires

Luminaires falling in this classification direct 60 to 90 per cent of their light output above the horizontal. They are either of the open or totally enclosed types made of glass, plastic or combinations of glass or plastic with metal. Typical examples of semi-indirect luminaires are shown in Fig. 3.

The ceiling colour is important where semi-indirect lighting is employed and should have a high reflection factor.

Indirect Luminaires

Indirect luminaires distribute 90 to 100 per cent of the light above the horizontal. Practically all of the light is directed to the ceiling and upper walls from which it is reflected to all parts of the room. Fig. 4 illustrates some of the indirect luminaires in use at present. These luminaires are often further described as being "opaque" or "luminous".

The "opaque indirect" are those having metal bowls or bodies which conceal the light source. The metal body may contain a mirrored glass reflector or the metal itself may be used as a reflector. "Luminous indirect" are made of dense glass or plastic or combinations of glass or plastic with metal. As indicated by their names these luminaires appear luminous when in use due to the downward distribution of not more than 10 per cent of the light. Well designed indirect luminaires have efficiences of 75 per cent or better.

With indirect lighting the ceiling becomes the light source providing light from all directions on the working plane which makes the shadows soft and con-

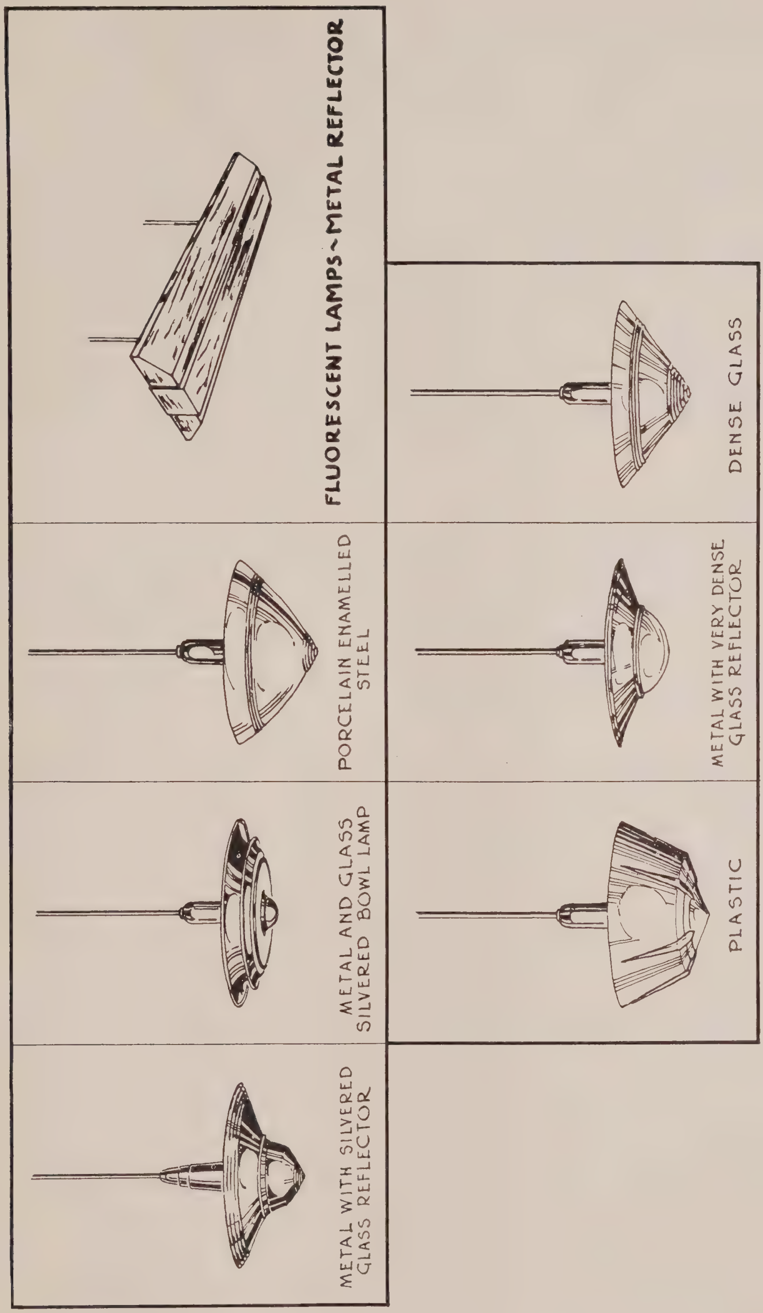


Fig. 4

siderably reduces the possibility of direct or reflected glare. The ceiling is important in the efficient utilization of the light and should have a high

reflection factor. Flat white paints are preferred with reflection factors in the neighbourhood of 85 per cent or flat ivory paints with reflection factors in the neighbourhood of 75 per cent.

Indirect and semi-indirect luminaires require larger lamps than semi-direct luminaires to provide the same quantity of light on the working plane. However, the quality of the lighting is very important for such locations as offices and schoolrooms in order to provide comfortable seeing conditions and for this reason indirect lighting is to be preferred.

Factors in the Selection of Luminaires

The selection of luminaires for any particular application is important and the illuminating engineer takes many factors into account such as

Will the desired illumination be provided?

Efficiency of the luminaire.

Brightness and brightness contrasts.

Reflected glare and harsh shadows.

Appearance, lighted and unlighted.

Flexibility.

Maintenance.

Mechanical and electrical construction.

The desired level of illumination for any seeing task is usually a compromise between what researches have shown to be beneficial and what is economically justified. The illuminating engineer is guided chiefly by tables of recommended foot-candles, for various locations, issued from time to time by the Illuminating Engineering Society. The illumination should be reasonably uniform which depends usually on the distribution of light from the luminaire and the distance between luminaires. Special consideration is required where illumination is required on the vertical as well as the horizontal plane.

The efficiency of a luminaire is the percentage of the light output of the bare lamp that is emitted by the luminaire. In commercial and industrial lighting applications the illuminating engineer strives to provide a reasonable amount of light at the working plane as economically as possible. It is evident therefore that the efficiency should be one of the deciding factors in the selection of the luminaire.

With the advent of larger lamps and higher levels of illumination, brightness and brightness contrast have become very important. The brightness of objects is measured in candles per square inch or foot-lamberts. The brightness of objects in the field of view determines whether or not the lighting is going to be comfortable. For this reason photometric tests of commercial lighting equipment include results of brightness measurements made at several locations and angles of view. The colour of the ceiling and walls and the size and shape of the room should also be considered in order to prevent brightness ratios greater than 10 to 1 in the normal field of view.

Reflected glare refers to the images of light sources or bright objects on the glossy surfaces of desks or other equipment and which are very annoying. Reflected glare reduces the effective illumination and causes eye-strain and should therefore be avoided.

The flexibility of a lighting system refers to its suitability for further increases in illumination or refinement. In some cases it costs very little more

to select luminaires that can accommodate a larger lamp than may be installed in the original installation. This also requires that the circuit wiring have adequate capacity for future load increases. In the case of fluorescent lamps the different wattages have different physical dimensions and it is therefore important that the original installation of a fluorescent lighting system provide adequate illumination in order to prevent costly changes.

A reduction of 30 per cent in light output of luminaires due to a few months' accumulation of dust and dirt is quite common. A reasonable efficiency can be maintained only by regular cleaning of the luminaires. It is not sufficient to wipe them off with a damp cloth, they should be removed and washed with soap and water or other cleaning solution. It is important that the luminaires selected must lend themselves to easy maintenance.

The author wishes to express his appreciation to the Lighting Service Section of The Hydro-Electric Power Commission for providing most of the illustrations.

Replacement of Pole

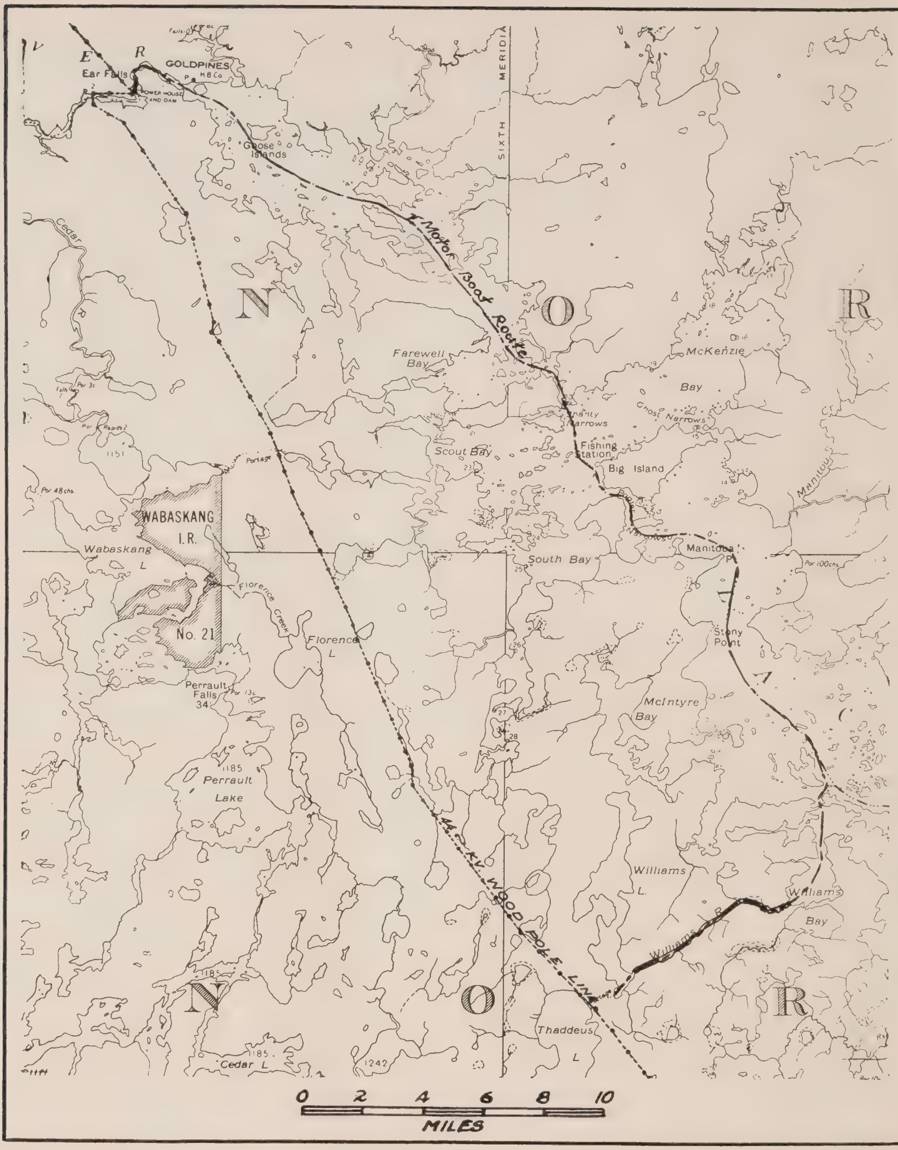
44 kv. Transmission Line, Patricia District, Northern Ontario Properties

By H. R. Graham, Assistant to System Operating Engineer, H.E.P.C. of Ontario

DURING a patrol of the 85 mile 44 kv. wood pole transmission line between Ear Falls generating station and the town of Sioux Lookout, one pole was found badly damaged by lightning to the extent that early replacement was considered advisable. This pole was located about 30 miles from Ear Falls in the midst of virgin forest and was rather inaccessible. In view of the isolated location, and the limited staff available, replacement presented a problem, but once again the ingenuity of Hydro patrolmen in the northern bush country arose to the occasion.

The woods adjacent to the weakened pole were searched but not a tree could be found from which a suitable pole could be cut. There was a spare pole stored on the line right-of-way, but this was three miles away. This was a 45-foot native spruce pole weighing approximately 1100 pounds. The next question was how to move this pole to the point where it was required. It was considered this could best be accomplished with the Caterpillar tractor and wagon from Ear Falls generating station. Accordingly these were loaded on a 15-ton scow secured from the Patricia Transportation Company. The scow was towed 35 miles up Lac Seul into Williams bay, thence up Williams river, about six miles, to the lower end of Williams lake. There the tractor and wagon were unloaded and run into Thaddeus overnight camp on the line right-of-way.

The scow was 48 feet long by 11



Map of part of Lac Seul showing route followed by repair crew.

feet wide. Down Lac Seul it was towed along side our Steelcraft motor boat "H.E.P.C. 2" but on the Williams river a tow line was used. For 1½ miles the Williams river is but a narrow creek and in this section it was necessary to pole the scow and the "H.E.P.C. 2" in order to navigate around the sharp bends. Along the remainder of the Williams river, the scow with the "H.E.P.C. 2" tied behind was towed in by means of the

canoe and outboard motor. It was considered inadvisable to operate the "H.E.P.C. 2" under power because of stumps and fallen trees in the river. It might be pointed out that the level of Lac Seul has been raised about 12 feet in the past eleven years and the shoreline, all the way to Williams lake is not clear of navigation difficulties.

The spare pole was hauled three miles north along the right-of-way to the damaged pole. In hauling, the butt of the pole was fastened on top of the rear axle of the wagon and the top end dragged along the ground. There were many stumps in the tote-road along the right-of-way. The tractors used during construction apparently had greater ground clearance and a wider track gauge than our smaller tractor. This meant that one track of our tractor ran in a rut and the other over the tops of the stumps. In some places the corduroy on the road was floating in water. Between the landing at Williams lake and the line right-of-way, 150 feet of road had to be built around a swamp. This was done by constructing a new corduroy road and running the tractor over it. Fortunately there were no bad hills on this section of the right-of-way.

The damaged pole was not used in connection with the raising of the new pole, because of its unsafe condition. The rock was removed from the crib and the hole beside the old pole enlarged down the rock, three feet below ground level. The butt of the new pole was placed on the side of the crib and the top raised by hand until it was about 20 feet from the ground. The tractor was then used to raise the pole to the vertical position. A rope was attached directly from the tractor to the pole, without using a gin pole. Side movement of the new pole during erection was prevented by the use of temporary guy lines. After the new pole was guyed in a vertical position, the old pole was stripped of cross arms, etc., all work being done from the new pole. The old pole was then jacked out and the crib refilled. The work permit for the replacement of the pole was in force one hour and twenty minutes.

The outgoing trip from Ear Falls to the damaged pole was accomplished in 29 hours with a seven hour tie-up overnight. The return journey from Thaddeus Camp to Ear Falls was made in about 16 hours. The four men taking care of this work were away from Ear Falls for 4½ days. Sufficient food for this period had to be taken along and the men cooked their own meals enroute.

Fundamental Problems of Energy

By Dr. Herbert Chatley

SPEAKING broadly, all the sources of power available to man derive directly or indirectly from the sun. Solar energy is principally received as radiation, amounting to two calories per sq. cm. per minute when the sun is overhead and the air is fully transparent. This is equivalent to about 1½ kw. per sq. m., but, owing to clouds, absorption in the atmosphere, departure of the sun from the zenith and the absence of the sun during the night, the mean effect is rarely more than one-quarter of this. Most of the energy is converted into the latent heat of water vapour, the warming of the soil, or the expansion or kinetic energy of the air and is ultimately lost again by the earth's radiation into space, the average temperature of the earth's surface remaining at a practically constant value determined by a nice balance between this incoming radiation from the sun and the equal but opposite radiation from the earth. There is, however, some storage of energy in organic materials, elevated water, and a very few mineral forms which, in fact, form our principal and definitely limited resources.

It may be computed that each sq. cm. of the sun's surface is pouring forth 6.24×10^{10} ergs per sec., or about 6 kw. The temperature there is of the order of 6,000 deg. C. and there is reason to think that this process has been going on for something like 10,000 million years. The actual output per gram per second is, contrary to popular belief, very small—only some 2 ergs. Small as this is, continued for this prodigious number of years, it totals to some 10,000 kw-hr. per gram, as compared with about 0.002 kw-hr. per gram for very active combinations of chemicals. Thus, the average substance of the sun has a total energy production some millions of times greater than that of earthly fuel combinations, but its activity (power rate) is extremely small. It seems probable that a central temperature of the order of 20,000,000 deg. C. is consistent with a gradual transformation of hydrogen into helium, carbon acting as a kind of catalyst, the radiation deriving from a small loss of mass in the hydrogen. In stars other than the sun there are some cases in which the rate of output is higher. The faint star known as HD1337A is reputed to have an output of 15,000 ergs per gram per second, but even this is extremely small compared with earthly fuels.

Within the earth there are minute quantities of certain substances, particularly the elements uranium and thorium, which are gradually transformed into simpler elements (principally lead). Of these, the intermediate form—radium—is one of the most stable and gives off in the course of some 3,000 years much the same energy as the sun's average material. The output per second is of the order of a million ergs per second per gram, but even so this is only about one ten-thousandth of a kilowatt per gram. Since a gram of carbon-oxygen mixture

From Chairman's address to the Junior Institution of Engineers, December, 1940.

will produce about 2,000 calories of heat, equivalent to 80,000 million ergs, or about one 500th of a kw-hr., and can easily be burnt in, say, 36 seconds (one hundredth of an hour), it can produce as heat one-fifth of a kw., vastly exceeding the *rate* of output of the radium. Hence, even radium, were it to be obtainable in large quantities, would not be at all a convenient form of power, in spite of the fact that the power would last for thousands of years.

While the cosmic sources are prodigious, they are very slow in action, and the chemical combinations on earth are capable of producing power at a far greater rate per unit mass. In ordinary fuels such as coal with comparatively small surface per unit mass, the contact with the air is limited and combustion is slow. With powdered fuels and a liberal air supply entering into the powder, combustion may be rapid, rising, in the case of fine coal-dust suspensions in air, to explosive conditions. Similarly, if oxygen-producing chemicals are mixed with carbon dust, as in the case of black gunpowder, the activity is very high. With high explosive the comminution is on a molecular scale, so that the combustion is only a matter of atoms changing position in the individual molecules; hence, the essential feature is usually a nitrogen compound which readily changes with fulmination (initial breaking down by another more unstable chemical change) or shock into a more stable form, often mainly simple nitrogen gas. The difference between the energy of combination of diatomic nitrogen and that of the original form is not often as high as that of carbon or hydrogen with oxygen, but the surface over which the change can occur is so enormous that the process is almost instantaneous. If, for instance, the molecules of a high explosive are one ten-millionth of a centimetre in diameter, one cubic centimetre contains one thousand million million million molecules and the mutual surfaces of contact are of the order of ten million square centimetres or one thousand square metres. It is quite feasible for such materials to give off energy for a fraction of a second at a power rate of thousands of horse-power per pound.

The natural storage of energy is either chemical or hydrostatic. In the case of coal or wood, solar radiation is stored in endothermic forms produced by the disintegration of carbon dioxide and water in plant life. Oil appears to have been largely due to animal (fish) life of former times and the formation of sulphur is an indirect process (possibly bacterial) which occurs in volcanic areas. As to hydrostatic storage, it need scarcely be remarked that this is due to solar radiation causing evaporation. Radioactivity is infinitesimally diffused, from an engineering aspect, and need not be considered. Artificial storage may take many forms but, with the exception of reservoirs, all are very inefficient.

The imports of mineral oil, some 11 million tons annually, are paid for by coal-produced manufactures or indirectly by the actual export of coal, so that, contrary to the popular belief, they do not add to our power resources, but simply put some of them in a form which is more convenient for certain purposes. The actual quantity of coal

used for power purposes is something like 120 million tons per annum (about 2 tons per acre of the whole island of Britain), or, say, 3 tons per head. Whereas, in labour and transport, coal of fairly good quality in the neighbourhood of London costs per ton the equivalent of about 48 hours in unskilled wages, its labour product, even in rather low-efficiency steam plant, is some 400 horse-power hours or about 4,000 man-power hours. In other words, even on a conservative reckoning, the power content of a ton of coal is some 80 times as great as the labour power required to win and carry it. Allowing as much as 100 per cent on the latter for the minding of the plant and the wear and tear on same, we still have a figure of 40 times, which will be much increased with high-efficiency plant and cheap dust coal. This difference is the main factor in the benefits of industrial civilisation. It is the source of the high standard of living, the short hours, the social services, the dividends of shareholders, the political and military position of Britain and all the other things which we think are due to our own cleverness.

In terms of present labour costs, the true value of a ton of good coal is about £100, or, to go to the other extreme, the value of a week's unskilled routine work of 48 hours is only about 1s., that being the present market price of the coal which will do the same amount of work. In modern factory design, it is well known that it will pay to invest about £500 in extra mechanical plant in order to save one workman. Since a perpetual annuity of about £20 a year can be bought with the same sum, and the coal required to replace the man's actual energy is less than 1 ton per annum, it is easy to see that practically the whole of the public service and the profits arising from the factory system actually derive from the low price of coal. This leads to another conclusion which is not at all welcome to certain parties, namely, that the export of coal at the mere cost of winning and transport is ridiculous. For every ton of coal we export, we are giving away future productive power, and only in a few cases (as with the purchase of oil) do we get a partially equivalent return.

Prior to the Nineteenth Century, the coal raised in England was very small in quantity, and was used practically entirely for domestic heating. The combined effect of technical developments and the machine factory was to raise the coal output during the century from a few million tons per annum to over 250 million tons in 1913, since which time it has remained at about that level. It is generally agreed that the present consumption can be maintained for several hundred years. On the other hand, the average depth from which coal has to be raised is steadily increasing, and while the cost is somewhat offset by the use of machinery for cutting, pumping, ventilating and hoisting, the difficulties of winning must increase with time.

The use of water, wind or solar radiation are all bound up with the problem of capital investment per horsepower, and the small quantity of energy per pound of medium. The case of water-power is the most favourable, but even here it must be re-

marked that a pound of water elevated to 778 ft. high has only an energy of 1 B.Th.U., so that, disregarding the efficiency of application, a pound of coal corresponds to an elevation of 1,500 miles. One ton of coal, as heat, is equal to 1 kw. year. Hence, it follows that, to obtain large water-power, reservoirs need to be of great height and capacity with correspondingly large costs for construction. The whole water-power resources of Great Britain would not cope with more than a fraction of the present consumption in the iron trade alone, which now uses 25 million tons of coal per annum, equal to 30 million h.p. considered as heat. Water currents are even more handicapped than elevated water. A natural velocity of 32 ft. per second, which is quite unusual, only corresponds to a free fall of 16 ft., so that the quantities of water which have to be handled to obtain reasonable quantities of power are prodigious. Wind power is open to the same difficulty, the volumes to be handled being 800 times greater than those of water for the same power. Differential heat effects, as between surface and bottom of sea water, or between ice and water, present some possibilities, but in all such cases the capital cost is very large. Solar radiation plant runs up against the same problem. The space required compels the plant per installed horse-power to be large, and, in many cases, it is as cheap to use the radiation for the production of fuel (wood or alcohol) as to attempt to transform it directly into useful heat. One method that the author has toyed with is the use of thermo-electric couples placed in the focus of solar mirrors, but the potential difference of each couple is so small that the internal electrical resistance of the whole apparatus is inconveniently high. There are, of course, certain localities where these methods can be usefully employed for local purposes, and in the case of water-power there can be no denying its complete success in specific areas.

Forestry and botanical studies have shown that some 2 ft. of rain per annum may be transpired by vegetation, and that the quantity of dry matter developed is about one-400th of the weight of the water transpired, or, say, 0.3 lb. per sq. ft. per annum, or about 6 tons per acre. The calorific value of such material is certainly less than half that of coal; this, then, means, say, 3 tons per acre per annum of coal equivalent. The total area of the vegetation surface of the island of Great Britain is under 50 million acres, so that it appears that if the whole of the island were devoted to the production of fuel, the quantity would still be less than the present mining output. Since, in fact, something like one-half the actual area is devoted to crops and pasture, it would be quite difficult to produce on the remaining land more than 75 million tons, and the labour required would greatly exceed that engaged in mining the present 250 million tons of coal. These figures throw a strong light on the vast scale of the present mining operations. If a ton of solid coal occupies 30 cu. ft., the present mining of 250 million tons means the excavation of 7,500 million cu. ft. of coal. The enormous quantity involved checks expansion, since it demands road and shipping services to correspond. If

the total thickness of the coal beds averages 10 ft., this means that each year some 25 square miles of coal-field is exhausted. In 350 years' time this equals 10 per cent of the whole area of the island.

The higher calorific value of oil, the ease of its manipulation, the higher efficiency of the internal-combustion engine and the weight of boilers or gas producers has compelled those nations lacking internal oil supplies to consider seriously the production of liquid fuel from coal. The conversion of the major part of the coal into liquid fuel involves chemical processes which absorb far more heat than is recoverable. Speaking broadly, it appears that about four times as much coal is required as is converted and the capital investment is very large. This result seems practically inevitable and the only sound conclusion appears to be that low-temperature processes are preferable, although they involve the use of much larger quantities of coal to produce the same quantity of oil, leaving the bulk of it in the form of non-volatile fuel. The main difficulty appears to be the enormous amount of carbonisation which is involved if adequate quantities of oil are to be obtained. It seems probable that the best course will be to use gas producers for as much as is possible of the land plant which is now operated by fuel oil, leaving the latter for marine and aerial use.

Various attempts have been made to measure human power with that of machines, and the general conclusion is that for prolonged operations the output of a man is about one-tenth of a horsepower. For short periods, strong men can exert power nearly up to one horsepower or for moderate intervals, say, one-third of a horsepower, but for steady work with average men and normal tasks the first figure seems about right. The Taylor-Gilbreth system of "scientific management" and "motion study" has shown how far this output can be steadily kept up, but it may be stated as a basic fact that, for repetitive operations carried out within a small space, or for pure transport, human labour is practically valueless as compared with natural power. Strong exception is taken by many to this soulless depreciation of human labour, but this is to a great extent mere sentiment; the very people who argue so, use mechanical substitutes for men all the time. —*Engineering.*

World's Supply of Aluminum

M. N. Hay, Works Manager, The Aluminum Company of Canada, Limited, Kingston, Ont.

METALLIC aluminum was first isolated in 1825 by the Danish chemist, Oersted, when he obtained a few globules of "the metal of clay" by a chemical method. Its commercial production was commenced in 1856 by Deville in France, by a slow and expensive method, the product costing about $90.00 a pound. One of the earliest commercial uses in a sizable quantity was the protective cap on the Statue of Liberty in New York harbour. It is interesting to note that Napoleon III subsidized the industry at its birth, thinking it might be useful for warlike purposes.

The process for recovering aluminum in use to-day, which inaugurated the industry's rather spectacular rise, was discovered in 1886 simultaneously by Charles M. Hall in the United States and Paul L. Heroult in France, each working independently. They laid down the essentials for the electrolysis of alumina, namely the use of fused cryolite capable of taking alumina into solution and then decomposing this solution electrolytically to release the metal. It was the invention, between 1870 and 1880, of the electric dynamo that made available the large amount of power necessary for the successful operation of this invention.

Because of these huge power requirements it is, therefore, natural to look for the development of the aluminum industry in those countries having potential sources of electric power, such as Switzerland, France, Norway, the United States and Canada, where hydro-electric power is available, and Germany with her coalfields.

For a clear understanding of the economics of aluminum production in the various producing countries, and the importance of aluminum as compared with other leading industrial nonferrous metals, it is essential to realize the phenomenal expansion of production as shown by yearly world output figures.

At first the output was very low. It is reported that in 1885 only a little over 15 tons were produced, but even this for such a new industry was quite an achievement. However, the rise was quite rapid and by the period of World War No. 1 annual production had increased to over 167,000 tons. After 1918 there was a slump followed by a rise, until in the boom years around 1929 an output of almost double the 1917 production was reached. During the depression which followed, production was on the decline, but rose again from 1934 to 1939 when a new high of over 800,000 tons was reached. With the present expansion all over the world for war requirements, 1940 and the next few years will prove the peak production years in the history of the industry.

Copper, lead, zinc and aluminum are the four leading non-ferrous metals. Their production, considered on a weight basis, of course, features the heavier metals, but when considered

From a Paper presented before the Kingston Branch of The Engineering Institute of Canada, on January 30th, 1941.

on a volume basis, copper, zinc and aluminum were practically equal in 1938. In that year the amounts by volume and weight were as follows:

	Cu. yds.	Short tons
Copper	288,000	2,165,585
Zinc	284,000	1,710,000
Aluminum	276,000	624,000
Lead	193,000	1,829,741
Nickel	14,000	105,000

Aluminum can be rolled, extruded, drawn, forged, pressed, spun and powdered or cast into sand, permanent mould or pressure die castings. With this range of properties and possible variety of products, it is no wonder that aluminum has come to hold such an important place in the industrial world.

Of the three essentials for the production of aluminum one, as already pointed out, is abundant electrical energy; the others are ample supplies of bauxite and coal. As will be shown later, good transportation for raw materials is also an important factor.

It is interesting to note that the principal items required to make one ton of aluminum are as follows:

25,000 kw-hr. of electrical energy.
4 tons of bauxite,
4 tons of coal,
1/3 ton of soda,
3/4 ton of carbon electrodes,
Small amounts of cryolite and fluoride salts.

Bauxite, the principal commercial ore of aluminum, derived its name from Les Baux, a little town in southern France where the ore was first discovered in 1821. Since then bauxite has been found in many localities throughout the world, chiefly in tropical or semi-tropical countries. In bauxite the aluminum is present as an oxide associated with varying amounts of impurities—iron, silicon and titanium oxides—free and combined water. Iron oxide, being red, colours the ore, and depending on the amount of iron present, ores from different localities vary from white, grey and pink to light brown and dark red.

Following is a list of the principal countries producing bauxite, with their outputs for 1938:

	Short Tons
France	750,685
Hungary	594,000
Surinam (Dutch Guiana)	414,920
British Guiana	420,640
Italy	396,920
United States	347,500
Yugoslavia	436,000
U.S.S.R.	275,000
Dutch East Indies	269,500
Greece	197,875
Misc.—Malay States, India, Brazil, Roumania, Germany	78,060
World Total	4,181,100

The initial processing of the bauxite ore is a chemical treatment in which, by the Bayer process, the ore is treated in a hot soda solution under pressure which separates the alumina (white, aluminum oxide) from the insoluble impurities commonly called red mud. It is in this part of the process that coal is required to provide the heat and steam pressure necessary to speed up the chemical reaction. The alumina, thus separated, is dried and then charged into electric furnaces where it dissolves in the molten cryolite bath.

The passage of an electric current through the bath reduces the aluminum oxide to metallic aluminum and oxygen. The metal, being heavier than the molten cryolite, sinks to the bottom of the furnace while the oxygen reacts with the carbon electrodes, forming carbon dioxide, and passes off as a gas. At periodic intervals the electric furnaces are tapped and the metal cast into pigs which are ready for remelting and alloying in the fabricating plants.

Only a few of the principal bauxite producing countries have the necessary coal and electric power for converting the bauxite into aluminum and even in this limited group, insufficient bauxite of the right grade, transportation problems between mines and power plants, or a lack of adequate electric power, all hinder the economical production of aluminum. There is, consequently, a very large international trade in bauxite.

Following is a list of the principal aluminum producing countries of the world in order of their assumed 1940 capacities.

The yearly output figures of any one country do not necessarily give a true picture of the economics of the aluminum industry in that country. This is particularly true in the case of Germany, which at the present time leads the world in tonnage output despite the fact that it does not have available limitless supplies of the necessary raw materials. Considering the tremendous increase in aircraft production in Germany, it is obvious that the Nazis have, regardless of cost, attempted to make themselves self-sufficient and have largely subsidized the industry in order to feed their vast war machine. It is interesting to note that since 1932, Germany's aluminum production has shown an almost tenfold increase to the output of 1939 and this represents almost one quarter of the total world production. Italy, Russia, Japan and even Norway and Switzerland have developed aluminum industries against economic barriers, although Norway and Switzerland have some justification inasmuch as those countries possess natural hydro-electric facilities.

	1938 (Short tons)	Assumed 1940 Capacities (Short Tons)
Germany	177,500	286,500
U.S.A.	143,200	220,000 (300,000—1942)
Canada	72,750	173,000
Russia	48,300	66,200
France	50,000	66,200
Italy	28,450	44,100
Norway	18,730	34,150
United Kingdom	25,700	33,100
Japan	18,730	30,000
Switzerland	29,750	27,550
Misc.—Hungary, Austria, Sweden, Yugoslavia, Spain	14,370	12,100

The ideal aluminum reduction plant would be one situated beside abundant bauxite deposits, adjacent to coal mines and with limitless cheap electric power readily available. The transportation of these raw materials, therefore, would not be a problem. Such an ideal location has not as yet been discovered although France most nearly approaches this condition.

In considering the economics of the aluminum industry, so many factors must be taken into consideration that definite rating of each country as to its suitability becomes almost impossible.

Power

Hydro-electric power in the industrial east of Canada needs no explanation. Northern Ontario and Quebec abound with waterways—potential sources of great power developments. Likewise, Norway, Switzerland have hydro-electric power in abundance. The United States is not so fortunate in that there is cheap power available only in New York State, the Southeast and the far West. France has good power developments but as most of these are built at the foot of deep valleys, utilizing high water heads but small volumes, the power plants have been limited in size. Russia has large power units, the most famous of which is the Dnieprostroi development, but the difficulty with the power developments in Russia, a fact which also holds for many of the best developments in Norway and Switzerland, is that they do not have a water accumulation in lakes back of the power plant to ensure a uniform volume of power throughout the entire year. As a result many of the Russian plants for part of the year are actually short of power, whereas in Canada, with the great chain of lakes and rivers in the north and the abundant snowfall, storage basins are kept at practically a constant level throughout the entire year. Power in Italy and Japan is very costly but being subsidized by the government, cost is a minor consideration. The situation in Germany is different because practically all of their electric power is produced from coal. Thus it is not surprising to find that the German reduction plants have nearly all been built in districts where brown coalfields exist and under these conditions power is made almost as cheap as in the average hydro-electric plant.

Bauxite

Of the important producing countries, France is the only one which has within her own borders abundant supplies of good grade bauxite. In the United States good deposits exist in Arkansas, Alabama and Georgia, but these will by no means provide sufficient ore for the large American industry, and most of the bauxite used at present by the States is imported from Dutch Guiana.

Germany, Russia and Italy have some deposits but they are mostly of an inferior grade. Germany and Italy depend largely on imports from the Balkan countries.

All other producing countries are without deposits of their own and are wholly dependent on imports.

Canada has to bring ore from distant British Guiana, but the quality of this ore is probably the best in the world. Transportation facilities by boat direct from the mines to the smelter are ideal, thus offsetting to a considerable degree the fact that we do not have any bauxite in our own country.

Coal

Canada, United States, Germany, France and the United Kingdom all have an abundant supply of coal. Russia and Japan both have limited deposits, while Italy, Norway and Switzerland are largely dependent on imports.

Transportation

Transportation—including necessary facilities for the handling of ore or raw materials—is a factor which cannot be rated with any certainty. Undoubtedly, France, with coal, bauxite, and power plants practically on the same property, has no transportation problem. Canada, Italy and the United Kingdom, importing as they do by sea, are in a more favourable situation than are most of the other countries. Norway and Japan, for instance, must haul by boat and then transport by rail considerable distances inland, greatly adding to the cost of transportation. The United States, while possessing a very efficient inland transportation system, has a necessity to make long haulages by rail as well as by boat in order to bring together all these raw materials from so many scattered sources of supply. In Germany they have a real problem, for practically all their ore has to come from the Balkan states by rail or river barge. Much of this traffic is on the Danube river, but because of the narrows at the Iron Gates, the boats and barges are small and shipping small tonnage is costly.

From this very cursory and generalized survey of the aluminum industry it is apparent that Canada should rightly hold a foremost place among world producers. True, there have been difficulties to overcome. At the mines in British Guiana there have been housing and sanitation problems as well as the difficulties of operating in tropical countries far from sources of supplies and equipment repairs. Our long winters in northern Quebec necessitate accelerated imports during the navigation season to provide stocks of raw material for the winter months. This, in turn, has required huge storage sheds and exceptionally large dock facilities to accommodate these supplies. Few people realize that the aluminum industry in Canada has developed and operated in Arvida the largest aluminum plant in the world, supplied by power from Isle Maligne, its own power-house, which is the third largest power-house in the world —560,000 h.p.—exceeded only by the American Boulder Dam and the Russian Dnieprostroi developments. Port Alfred, the fourth largest port in Canada, also was built for the aluminum industry's immense boat traffic.

—*The Engineering Journal.*

Fears and Favours

THE *London Advertiser* of June 6, 1908, carried an editorial from which the following is quoted.

Has the Hon. Adam Beck become a mono-maniac on the power question? His wild and extravagant assertions have justified the suspicion were it not that they are timed and calculated for election purposes.

In a flight of imagination during his speech the other evening he declared that every cottage, every house, every home in this City will be lighted by electricity. His power scheme would raise men's wages, give two cent fares on the railroads, and banish the tenements from Ontario. The taxpayers, he went on, would not pay one cent of the cost which would be borne entirely by the consumers of power.

His newspaper organ lets its fancy soar even higher and pictures the housewife heating her flat irons by electricity—why not her curling tongs, too—instead of sweltering before a hot stove on a summer's day. If all the Arabian Nights rhetoric of Mr. Beck and his organ is to be believed Niagara Power is a gift of the fairies to the humblest as free as air so that by and by the householder will merely have to touch the button and the Beck scheme will do the rest.

There is little moral difference between the absurd misrepresentations of Mr. Beck and the sort of appeal made by Gamey of Manitoulin, when he told the people of Temiskaming that the election of the Government candidate meant a larger expenditure in that riding. There is this difference that Gamey will be in a position to deliver the goods if the Government is returned to power while Mr. Beck will never be able to give effect to the reckless promises which he is dangling before the electors. He is giving them promissory notes which he will never be able to redeem.

(In the same article the *Advertiser* foreshadows the cost of Niagara power in London at $56.03 per horsepower at a consumption of 2,200 h.p. or $44.62 for 3,000 h.p., which is more than double the actual figures prevailing. It asks if any intelligent business man believes there is a market in London for 5,000 h.p.)

Where, the question may be asked again, is a market for 5,000 h.p. to be found and, if a market for 5,000 h.p. cannot be found at once what will the predicament of the taxpayers be or the consumers of Niagara power? The less the quantity of power taken the higher must be the price, and, if a municipality can handle only 3,000 h.p. it must charge its customers at the rate of $44.62 per h.p. to make both ends meet. If it can handle only 2,250 h.p. it must charge $56.03 to clear itself, but how can it hope to create a market at such figures.

The fact is that when the Hydro Electric contract is signed the ratepayers will be face to face with a probable increase in taxation of 2 or 3 mills on the dollar to make good the difference between the credit and debit sides of the power ledger, until such time as there is sufficient market to enable the city to balance accounts. No one can foresee when that time can come. The whole thing is a gamble, a huge speculation. There is no ele-

ment of certainty except that the ratepayers of London assume all risk.

The foregoing editorial was written shortly after London and thirteen other municipalities had entered into the original agreement with The Hydro-Electric Power Commission. By that agreement London contracted for 5,000 horsepower at an estimated cost of $23.50 per horsepower per year. The first delivery of power was taken in December, 1910, when the maximum load was 805 horsepower. In October, 1914, London load exceeded the amount of the contract. The average monthly load recorded for 1940 was 37,280.9 horsepower at a cost of $23.54 per horsepower per year. For the fiscal year 1941 the average monthly load was 38,667.3 horsepower. Prior to Hydro domestic and commercial lighting service was supplied at nine cents per kilowatt-hour plus twenty-five cents per month meter rental. In 1940 the net cost per kilowatt-hour for domestic service was one cent and for commercial lighting service 1.2 cents. These statistics indicate that the fears expressed in the editorial have not materialized.

Dr. J. S. Plaskett, C.B.E., F.R.S.

DR. John Stanley Plaskett, the distinguished Canadian astronomer, died at Victoria, British Columbia, on October 17. The son of the late Joseph Plaskett, he was born near Woodstock, Ontario, on November 17, 1865, and educated at Woodstock High School. It is stated that, owing to the death of his father when he was 14 years of age, young Plaskett spent some years on the family farm. From his early years, however, he had shown an aptitude for mathematics, and in 1885 was apprenticed with the Edison Electric Company at Schenectady. In 1889, he was given a position in the Canadian Edison Company at Sherbrook, but soon afterwards entered Toronto University as assistant in the Physics Department. He made the most of his opportunities and, in 1899, graduated B.A., with first-class honours in mathematics and physics. He then took up scientific photography and his work in this sphere, combined with his experience in engineering and also in spectroscopy, gained for him a position in the Astronomical Branch of the Canadian Department of the Interior, Ottawa, in 1903. The two following years were spent on the design and testing of the spectroscopic equipment for the 15-in. telescope which was being constructed for the Dominion Observatory at Ottawa. In 1905, Dr. Plaskett was given charge of the Canadian Eclipse Expedition to Labrador, and, in recognition of his services, was promoted to the position of astronomer of the Dominion Observatory at Ottawa on his return.

In 1906, he designed a new spectroscope for the determination of stellar radial velocities, and in 1909 made a series of observations for the spectroscopic determination of solar rotation. It became evident that work was being hampered for the lack of a telescope larger than the 15-in. instrument at

Ottawa and mainly owing to Dr. Plaskett's efforts a 72-in. reflecting telescope was set up at the Dominion Astrophysical Observatory, Victoria, British Columbia, of which he was made director in 1917. He continued in this capacity until his retirement in 1935, gaining an international reputation for his work on the velocities and characteristics of the O-type stars, the dimensions of eclipsing variables, and other matters. These researches resulted in the discovery of a massive and bright star which was named the "Plaskett Star." He was the recipient of many honours, among them being the honorary degree of D.Sc. of Pittsburgh and Toronto Universities and that of LL.D. of the Universities of British Columbia; McGill, Montreal; and Queen's, Kingston, Ontario. He was made a Fellow of the Royal Astronomical Society of Canada in 1907, a Fellow of the Royal Society of Canada in 1910, and a Fellow of the Royal Society in 1923. He was awarded the Rumford Premium of the American Academy of Arts and Sciences, the George Darwin Gold Medal of the Royal Astronomical Society in 1930, and the Bruce Medal of the Astronomical Society of the Pacific and the Flavelle Medal of the Royal Society of Canada in 1932. He was made a C.B.E. in 1935.—*Engineering.*

E. J. Stapleton, Collingwood

On Saturday, November 22, 1941, Edward J. Stapleton, former superintendent of the Collingwood Public Utilities Commission died suddenly in Collingwood aged 69 years.

"Ed" was born in the village of Templemore, county of Tipperary, Ireland, coming to Canada forty years ago. He first settled in Paris, Ontario where he remained for some years associated with the public utilities. Later he moved to St. Marys where he had charge of the municipal water and light plants. In 1911 he went to Collingwood as superintendent of the local utilities where he continued until 1936, directing the electric and water departments. To him Collingwood was his home, where he had many friends who knew him long and well. He was a director of the G. and M. Hospital for ten or more years, and also a trustee of the public library for a long period. At the time of his death he was serving on the separate school board.

He was widely known and highly respected in Hydro circles. While with the Collingwood Commission he took an active interest in the Association of Municipal Electrical Utilities and served for a number of years on the executive. He was also active in the Georgian Bay Municipal Electric Association, where he was also a member of the executive.

Convention Programmes

THE Annual Meeting of the Ontario Municipal Electric Association and the Winter Convention of the Association of Municipal Electrical Utilities will be held at the Royal York Hotel, Toronto, on Tuesday and Wednesday, February 10th and 11th, 1942. The programmes of the two associations in so far as arrangements have been completed are outlined in the following.

There will be one joint session of the two associations on the afternoon of Tuesday, February 10th; each association will hold three separate sessions, namely, one on the morning of the first day and one each on the morning and afternoon of the second day. Convention luncheons and dinner will be held jointly; on Wednesday, February 11th, the two associations will be the guests of the Electric Club of Toronto.

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Electrical Employers Association Meeting

The Electrical Employers Association of Ontario will hold a dinner meeting on the evening preceding the convention, Monday, February 9th. This meeting will be at the Royal York Hotel, beginning at 6:00 p.m. There will be short addresses on Accident Prevention and the work of the Electrical Employers Association, and also a general Round Table conference. Officers of the Electrical Employers Association for 1942 and also its Managing Committee will be elected.

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O.M.E.A.

The programme of the Ontario Municipal Electric Association Annual Meeting, and also the session and other functions to be held jointly with the Association of Municipal Electrical Utilities will be as follows:

Monday, February 9th.

Evening at 6:30 o'clock.

Executive Dinner, immediately followed by a meeting of the Executive Committee.

Tuesday, February 10th.

Morning.

9:00 o'clock, Registration.

10:00 o'clock, Convention Session.
Minutes
President's Address
Secretary's and Executive's Report
Treasurer's Report
Resolutions.

Afternoon.

12:30 o'clock, Convention Luncheon, held jointly with the A.M.E.U. Address.

2:30 o'clock, Convention Session held jointly with the A.M.E.U. Address by Dr. Thomas H. Hogg, Chairman and Chief Engineer, The Hydro-Electric Power Commission of Ontario.
Discussion.

6:30 o'clock, Convention Dinner with the A.M.E.U. Address.
Musical Entertainment.

Wednesday, February 11th.

Morning.

9:30 o'clock, Convention Session.
Reports of Committees
Credentials
Resolutions
Finance
Convention
Election of Officers
Unfinished Business
New Business
General Discussion

Afternoon.

12:30 o'clock, Convention Luncheon. The delegates will attend the regular weekly luncheon of the Electric Club of Toronto along with the A.M.E.U. Address.

2:30 o'clock, Convention Session. District Reports and discussion on same.
The new Executive Committee will meet immediately following the close of this session.

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A.M.E.U.

The Association of Municipal Electrical Utilities convention programme will follow the order outlined below. For such parts as will be held jointly with the Ontario Municipal Electric Association, the reader is referred to the O.M.E.A. programme outlined above.

Tuesday, February 10th.

Morning.

Registration.
10:30 o'clock, Convention Session.
President's Address.
Auditor's Report.
Reports of Committees.
Paper, "Industrial Motor Efficiency" by W. R. Harmer, Supervising Industrial Engineer, H.E.P.C. of Ontario, Toronto.
Discussion.

Afternoon.

12:30 o'clock, Convention Luncheon with the O.M.E.A.; see O.M.E.A. programme.

2:00 o'clock, Convention Session. Election of Officers for 1942.
Joint Session with the O.M.E.A.; see O.M.E.A. programme.

Evening.

6:30 o'clock, Convention Dinner with the O.M.E.A.; see O.M.E.A. programme.
Executive Committee Meeting. The newly elected officers will meet immediately after the Convention Dinner for the purpose of planning for 1942 activities.

Wednesday, February 11th.

Morning.

8:00 o'clock, Breakfast Meeting and discussion conducted by the Committee on Accounting and Office Administration.

9:30 o'clock, Convention Session. Moving Picture Film, "Collection of Delinquent Service Bills" by H. J. Offer, Supervisor of Collections, Detroit Edison Company, Detroit, Mich.
Discussion.

Addresses, "Problems Resulting from the War" led by M. J. McHenry, Priorities Officer, H.E.P.C. of Ontario, Toronto.
Discussion.

Afternoon.

12:30 o'clock, Convention Luncheon, with the O.M.E.A. and the Electric Club of Toronto; see O.M.E.A. programme.

2:30 o'clock, Convention Session.
Papers, "Hot Line Operation" by H. J. Muehleman, Operating Engineer and E. R. Lawler, Assistant Engineer, H.E.P.C. of Ontario, Toronto.
Discussion.

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A.M.E.U. Elections

The elections of officers for the year 1942 will be on Tuesday, February 10th. Delegates will obtain their ballots when registering or before the opening of the convention session on the afternoon of that day. Immediately after that session opens, the ballot will be closed and the scrutineers will make their report before the session adjourns. The ballots will show the following as candidates:

President:
V. A. McKillop, London, Acclamation.

Vice-President:
R. B. Chandler, Port Arthur; R. J. Smith, Perth.

Secretary:
S. R. A. Clement, H.E.P.C. of Ontario, Toronto, Acclamation.

Treasurer:
F. A. Archer, H.E.P.C. of Ontario, Toronto; G. E. Conn, H.E.P.C. of Ontario, Toronto.

Directors (from the Membership at Large, Three to be elected):
A. W. Bradt, Hamilton; W. R. Catton, Brantford; G. E. Chase, Bowmanville; A. L. Farquharson, Brockville; H. R. Hatcher, Galt; A. B. Manson, Stratford; O. C. Thal, Kitchener; P. B. Yates, St. Catharines.

District Directors:

Niagara District—
J. W. Peart, St. Thomas; R. S. Reynolds, Chatham.

Georgian Bay District—
R. S. King, Midland; J. R. McLinden, Owen Sound.

Central District—
C. A. Walters, Napanee, Acclamation.

Eastern District—
S. W. Canniff, Ottawa; W. B. Reynolds, Brockville.

Northern District—
R. H. Martindale, Sudbury; C. J. Moors, Fort William.

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Hotel Rates

The Royal York Hotel is giving the same convention rates as formerly, namely, $3.50 per person, single and $3.00 per person if two in a room.

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Reduced Railway Fares

The associations have arranged for reduced railway fares for delegates and their families attending the convention of fare and one-third, plus 25 cents,

minimum round trip fare $1.25. Delegates will receive certificates with their convention notices which they will present when purchasing their tickets, and receive return tickets at the reduced rate. One certificate is required for each delegate, which will include members of his family as well as himself.

Tickets will be sold from February 6th to 11th inclusive, Return Limit, thirty days in addition to date of sale.

Delegates are urged to come to the convention by railway and thereby save gas.

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